NAVY
PROPOSAL SUBMISSION

INTRODUCTION:

The responsibility for the implementation, administration and management of the Navy STTR program is with the Office of Naval Research (ONR). The Navy STTR Program Manager is Dr. Peter Majumdar. If you have questions of a general nature regarding the Navy's STTR Program, contact Dr. Majumdar (Peter_Majumdar@onr.navy.mil). For inquiries or problems with electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8AM to 5PM EST). For technical questions about a topic, contact the Topic Authors listed under each topic before **19 Feburary 2007**. Beginning **20 February**, for technical questions you must use the SITIS system **www.dodsbir.net/sitis** or go to the DoD website at http://www.acq.osd.mil/osbp/sbir for more information.

The Navy's STTR program is a mission-oriented program that integrates the needs and requirements of the Navy's Fleet through R&D topics that have dual-use potential, but primarily address the needs of the Navy. Companies are encouraged to address the manufacturing needs of the Defense Sector in their proposals. Information on the Navy STTR program can be found on the Navy STTR website at **http://www.onr.navy.mil/sbir.** Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the website at **http://www.navy.mil.**

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format, submission instructions and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I base should be 7 months and will commence on or about 01 July 2007. The Phase I option should be 3 months and address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. Phase I technical proposals, including the option, have a 25-page limit (see section 3.4). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

All proposal submissions to the Navy STTR Program must be submitted electronically. It is mandatory that the **entire** technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR/STTR Submission website at **http://www.dodsbir.net/submission**. This site will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents is submitted separately through the website. To verify that your technical proposal has been received, click on the "Check Upload" icon to view your uploaded technical proposal. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-866-724-7457 (8AM to 5PM EST). Your proposal **must** be submitted via the submission site before **6:00 a.m. EST, Wednesday, 21 March 2007**. An electronic signature is not required when you submit your proposal over the Internet.

Within one week of the Solicitation closing, you will receive notification via e-mail that your proposal has been received and processed for evaluation by the Navy. Please make sure that your e-mail address is entered correctly on your proposal coversheet or you will not receive a notification.

PHASE I ELECTRONIC SUMMARY REPORT:

In addition to the final report required in the funding agreement, all awardees must electronically submit a non-proprietary summary of that report through the Navy SBIR/STTR website. It must not exceed 700 words and should include potential applications and benefits. Submit the summary at **http://www.onr.navy.mil/sbir**, click on

"Submission", and then click on "Submit a Phase I or II Summary Report". This summary will be publicly accessible via the Navy's Search Database.

PHASE II PROPOSAL SUBMISSION:

Phase II proposal submission is by invitation only. Only those Phase I awardees who achieved success in Phase I, measuring the results achieved against the criteria contained in section 4.3, will be invited to submit a Phase II proposal. If you have been invited to participate, follow the instructions provided in the invitation. The Navy will evaluate and select Phase II proposals using the evaluation criteria in the DoD solicitation. All Phase II proposals must be submitted electronically through the DoD SBIR/STTR Submission website.

Under the new OSD (AT&L) directed Commercialization Pilot Program (CPP), the Navy SBIR/STTR program will be structuring more of our Phase II contracts in a way that allows for increased funding levels based on the projects transition potential. This will be done through either multiple options that may range from $250K to $1M each, substantial expansions to the existing contract, or a second phase II award. For currently existing phase II contracts, the goals of the CPP will primarily be attained through contract expansions, some of which may significantly exceed the $750K recommended limits for Phase II awards not identified as a CPP project. All projects in the CPP will include notice of such status in their Phase II contract modifications.

All awardees, during the second year of the Phase II, must attend a one-day Transition Assistance Program (TAP) meeting. This meeting is typically held during the summer in the Washington, D.C. area. Information can be obtained at **http://www.dawnbreaker.com/navytap**. Awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary through the Navy SBIR/STTR website at the end of their Phase II.

PHASE II ENHANCEMENT:

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy STTR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy may provide a one-to-four match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional STTR funds for $1,000,000 match of acquisition program funding can be provided, as long as the Phase III is awarded and funded during the Phase II.

ADDITIONAL NOTES:

1. Proposals submitted with Federal Government organizations (including the Naval Academy, Naval Post Graduate School, or any other military academy) as subcontractors will be subject to approval by the Small Business Administration (SBA) after selection and prior to award.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages **will not** be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR/STTR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR/STTR Phase II it will not count against them.

3. Any contractor proposing research that requires human, animal and recombinant DNA use is advised to view requirements at website **http://www.onr.navy.mil/sci_tech/ahd_usage.asp**. This website provides guidance and notes approvals that may be required before contract work may begin.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. Make sure you have added a header with company name, proposal number and topic number to each page of your technical proposal.

____2. Your complete STTR Phase I proposal (coversheet, technical proposal, cost proposal, and DoD Company Commercialization Report) has been submitted electronically through the DoD submission site by 6:00 a.m. EST, Wednesday, 21 March 07.

____3. After uploading your file and it is saved on the DoD submission site as a PDF file, review it to ensure that it appears correctly.

____4. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

Navy STTR 07 Topic Index

Navy STTR 07 Topic Descriptions

N07-T001 TITLE: Accurate Computational Prediction of Headed Plume Characteristics Emanating from Non-Conventional Exit Shapes in a Cross Wind Environment

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop computational fluid dynamic (CFD) codes to capture the flow physics and characteristics of heated plumes from both traditional and non-traditional exhaust exits in the presence of crosswinds. Develop a validated tool for use by Navy programs to accurately predict plume characteristics based on various configurations of exit geometries, temperature and velocity ratios.

DESCRIPTION: Heated air emanating from exhaust exits can have significant impact on other systems that may reside downstream or above such as antennas, radio systems, control surfaces, or even personnel and other aircraft on a flight deck. There exists a need to predict the characteristics of these heated plumes emanating from non-conventional exit shapes. Many years of research literature is available concerning submerged and heated plumes emanating from traditional circular or near circular exits both with and without a crosswind. However, there does not currently exist a reliable validated computational code for plume prediction, especially for non-traditional shapes and groups of shapes. To date, very little literature is available for heated plumes in a crosswind emanating from slotted or high aspect ratio nozzles.

Computational codes are sought that are able to accurately predict the very complex flow field and characteristics of these 'non-conventional' shaped plumes. The ability to predict the temperature and behavior of heated plumes will be helpful for helicopter, fixed wing, and surface ship engine exhaust system designs. Flow physics and characteristics for several configurations of exhaust geometries (planform aspect ratio of exit shapes from 1 to 20), temperature ratios (exhaust to ambient) of about 2 to 10, and momentum ratios (exhaust to ambient) of about 1 to 5, will need to be studied and evaluated for the near field, mid and far field locations (from zero to 50 reference lengths from the exit). Resulting computational codes must provide accurate predictions to within 5% of the temperature ratio at any point in the heated flow field up for various turbulence levels of flow. If computational codes can be validated, a tool is sought that could accurately predict the characteristics and flow field of heated plumes based on geometry, temperature, and velocity inputs.

PHASE I: Determine the feasibility of computational codes to predict the characteristics of heated plumes exiting from circular, and high aspect ratio nozzles in a crosswind, both singularly and in groups. Determine what measurements and non-dimensional parameters will be essential for evaluation. Design initial experimental models.

PHASE II: Build many prototype model shapes and complete a series of experimental measurements while developing the computational tools that will be used for comparison to the experimental results. Accurate experimental measurements are essential for success. Several computational codes and physical model shapes should be compared and refined. The plume characteristics of singular and groups of exhaust systems should be studied and evaluated. State the accuracy of the predictions for all conditions listed above.

PHASE III: Investigate the scalability of the Phase II results and show that the code predictions are accurate for an exhaust size geometric scale factor of at least 20. Finalize the computational code and prediction tool designs. Transition the technology for use in a Navy program.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This code and resulting prediction tool could be applied to any commercial vehicle that emits heated exhaust. It could also be applied to power plants and other large industrial facilities that emit large volumes of hot exhaust into the atmosphere.

REFERENCES:
1.“Computational and Experimental Assessment of Jets in Cross Flow”, Agard Conference Proceedings 534, April 1993.

2. Margason, R.J. “Fifty Years of Jet in Cross Flow Research”, NASA Ames Research Center, N94-28004, April 1993.

3. Higgins, C.C., et.al, “Exhaust Jet Wake and Thrust Characteristics of Several Nozzles Designed for VTOL Downwash Suppression,” NASA Report CR-373, Jan 1966.

4. Chiu, S. et al, “A Numerical Investigation of a Subsonic Jet in a Crossflow,” AIAA 93-0870, AIAA 31st Aerospace Sciences Meeting and Exhibit, Jan 1993.

KEYWORDS: Submerged Jet; Plumes; Crossflow; Computational Fluid Dynamics; Aerothermodynamics; Slotted Plumes; High Aspect Ratio Plumes; Heated Plumes

N07-T002 TITLE: Aircraft Battery Diagnostic and Prognostic System

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PMA-260/Aviation Support Equipment; JSF/Joint Strike Fighter; PMA-263

OBJECTIVE: Develop diagnostic and prognostic technologies for aircraft batteries and integrate these into the maintenance community and the overall vehicle health management system to provide a cost savings while increasing safety and readiness.

DESCRIPTION: Navy aircraft currently use Lead Acid, Nickel Cadmium and Lithium Ion batteries. The current schedule-based maintenance practice is to simply remove and replace the batteries. Most batteries get replaced after they have been in service for three years or less. The Navy suspects that many of the batteries actually have a useful life around six years.

A battery diagnostic capability is sought to correctly diagnose the ability of batteries to hold charge, measure charge capacity and state of charge, as well as identifying battery failure modes such as but not limited to: overcharging, overheating, shorted cells, loose connections, dry shorts, and sulfation.

The intent of this topic is to research and develop an innovative battery diagnostic and prognostic system for aircraft use. Some technical challenges to be addressed include, but are not limited to, 1) characterizing the failure modes that occur in batteries and correlating these failures to the health of the battery, 2) developing appropriate algorithms to differentiate between these failure modes and normal aircraft operational modes and environments, 3) simplifying data analysis and developing a graphical user interface that is easily interpreted by the maintenance community, 4) develop and package the technology to withstand the harsh aircraft environment, and 5) packaging and integrating the technology into the aircraft electrical power system and vehicle health management system.

PHASE I: Define and determine the feasibility of a technical approach; develop an implementation plan for integrating the battery diagnostic technology into support equipment and/or naval air vehicles; validate the approach either through analytical means or through provision of test data or bench top hardware.

PHASE II: Design and develop a prototype battery diagnostic and prognostic system. The prototype will be tested on valve regulated lead acid, nickel cadmium, or lithium ion batteries by maintenance personnel. Demonstrations may be performed in a high-fidelity laboratory environment and/or aircraft ground demonstration.

PHASE III: Package and integrate diagnostic/prognostic technology. Perform a functional evaluation of the technology (including flight demonstration if necessary).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The results of this work can be commercialized to provide diagnostic and prognostic systems that can detect battery anomalies in space, sea, air, and land vehicles. This technology will result in an increase in safety and reliability for these vehicles while also reducing maintenance costs, unnecessary replacement of batteries, and the amount of hazardous waste and cost of procurement by extending the service life of the battery. Commercial airlines are specifically interested in diagnostic technologies for battery systems. Also, the results of this work can be applied to consumer battery products and industrial applications such as Uninterruptible Power Supplies (UPSs). Other private sectors that face similar battery system degradation and safety concerns include the power utilities, automotive industry, and production plants.

REFERENCES:
1. “For HUMS Read Improved Safety” and “The Technology Behind HUMS”, Smiths Industries Aerospace Review, Number Seventy, Winter 2000, pgs 6-13, www.smithsind-aerospace.com.

2. “Hardware Advances and Development of Effective Solutions for Battery Management in Military Applications”, M. Mattera, PowerSmart Inc., Proceedings of the 40th Power Sources Conference, Session 27, 10-13 June 2002.

3. “Fuzzy-Logic-Based Smart-Battery State-of-Charge (SOC) Monitor for SLI Batteries”, P. Singh, Villanova University and H. Chen, X. Wang, D. Reisner U.S. Nanocorp, Proceedings of the 40th Power Sources Conference, Session 27, 10-13 June 2002.

KEYWORDS: Battery Systems; Diagnostics and Prognostics; Health Management; Condition Based Maintenance; Electrical Power; Lead Acid; Nickel Cadmium; Lithium Ion

N07-T003 TITLE: Deployable Intelligent Projection Systems for Training

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

ACQUISITION PROGRAM: PMA-205 Aviation Training Systems

OBJECTIVE: Develop innovative computer algorithms and associated technologies (as appropriate) to support automatic and continuous estimation and correction of geometric and photometric errors to enable the use of a small set of cooperating “intelligent” projectors (integrated projection and sensing) to create a single seamless wide-area (panoramic) image as part of a deployable visual training system for multiple viewers.

DESCRIPTION: Recent advances in projector technologies, off-line display calibration, and rendering algorithms have made possible the use of multiple overlapping projectors to create a visually seamless wide-area image on many unprepared-prepared, every-day surfaces. The intent of this topic is to develop intelligent projection systems and methods to be used as an integral part of deployable visual training systems. One key challenge to the success of such applications is developing a method to effectively calibrate (estimate) the relative geometric and photometric parameters of the projectors and imagery to facilitate the necessary warping and blending. Researchers have had initial success through use of embedded sensors [1] and off-line passive approaches [2]. Proposed solutions or systems must be robust to physical and electrical perturbations over time, adjusting automatically and continuously during use [3]. Through an application of multiple polarized projected images, it may be possible to provide individual viewpoints for two or more users immersed in the same simulation [4].

PHASE I: Demonstrate feasibility of proposed innovative methodologies and/or tools to provide automatic and continuous estimation and correction of projected imagery from a small overlapping set of casually configured conventional or intelligent projectors. Identify corresponding algorithm and device possibilities and tradeoffs related to complexity of use and implementation, robustness, and reliability.

PHASE II: Develop a prototype multi-projector deployable display system using the chosen intelligent projectors (technologies). Adapt/modify an example existing visual training application (software) to function with the prototype, and demonstrate the automatic and continuous geometric and photometric calibration capabilities.

PHASE III: Install and test prototype multi-projector display system (with automatic and continuous calibration) within a system providing shipboard training capability.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The simulation based training and entertainment industries will benefit as the need for expensive wall-mounted (or head-mounted) visual image generators would no longer be required. Projectors that could correct screen distance, screen angles, curves and dimensions, and that in addition automatically adjust to properly overlap images for immersive surround-screen imaging would enable simulations to be conducted in any room. With the addition of corrections for multiple viewpoints, several trainees could participate in a 2D or 3D simulation simultaneously.

REFERENCES:
1. Lee, J. C., Dietz, P. H., Maynes-Aminzade, D., Raskar, R., and Hudson, S. E. 2004. Automatic projector calibration with embedded light sensors. In Proceedings of the 17th Annual ACM Symposium on User interface Software and Technology (Santa Fe, NM, USA, October 24 - 27, 2004). UIST '04. ACM Press, New York, NY, 123-126.

2. Raskar, R., Brown, M., Yang, R., Chen, W., Welch, G., Towles, H., Seales, B., and Fuchs, H. 1999. Multi-Projector Displays Using Camera-Based Registration, in Proceedings of the Conference on Visualization 99: Celebrating Ten Years (San Francisco, CA, USA, October 24 - 29): 161-168.

3. Yang, R. and Welch, G. 2001. Automatic and Continuous Projector Display Surface Estimation Using Every-Day Imagery," presented by Herman Towles at the 9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (Plzen, Czech Republic, 2001).

4. Hendriks, E. A.; Redert, A. Real-time synthesis of digital multiple-viewpoint stereoscopic images, SPIE Proceedings Vol. 3639 pp.266-276.

KEYWORDS: Projection; Simulation; Intelligent; Visual display; Training; Multiple-viewpoint

N07-T004 TITLE: <u>Autonomous UAV Aerodynamic Performance Analysis for the Near-Ship Environment</u>

TECHNOLOGY AREAS: Air Platform, Information Systems, Battlespace, Space Platforms

ACQUISITION PROGRAM: PMA-263 Unmanned Air Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this topic is to create rapid, low-cost modeling and simulation techniques that couple aircraft aerodynamics and flight controllers with the near-ship aerodynamic environment. Performance predictions will be of sufficient fidelity to alleviate live article flight testing with virtual flight testing.

DESCRIPTION: Operational flight envelopes for UAV shipboard operations are based solely on at-sea flight testing. UAV flight testing is necessarily conservative because the air vehicles are often unconventional configurations and are flown by software as opposed to pilots. These two complicating features (unconventional configurations and software pilots) combined with the normal complications of at-sea flight testing results in very conservative operational flight envelopes. Modeling and simulation (M&S) is a natural avenue to pursue to alleviate the flight test burden currently imposed on UAVs. However, currently available M&S techniques have serious limitation that render the approach virtually useless for acquisition programs. The main barrier is analysis turn around time in conjunction with required levels of physical fidelity. Computation fluid dynamics techniques have proven useful in both the arenas of aircraft performance predictions and ship suitability simulation (Ref. 1-5). However, the previously mentioned work required months of computer time for a handful of solutions. In order to be useful as a test and evaluation analysis tool, analysis of similar fidelity must be available with an order of magnitude reduction in turn around time.

A relatively fast, high-fidelity means of simulating operation flight testing for UAVs is sought. Fidelity levels will be judged relative to fully coupled ship and aircraft computational fluid dynamics (CFD) calculations and available wind tunnel and flight test data if applicable. Fully coupled CFD methods can require on the order of 150,000 CPU hours and 24 days of wall clock time for a thirty second approach of a rotary wing vehicle using blade element modeling. An order of magnitude reduction in CPU time and wall clock time is sought while maintaining fidelity levels of integrated forces and moments to within 20% of fully coupled predictions and matching force and moment trends along the flight path. Both fixed-wing and rotary-wing UAVs are of interest. Modeling of other aircraft systems, such as flight controls and autonomous controllers, coupled with the aircraft aerodynamics will be required to predict how a UAV will react to an unsteady ship airwake environment.

PHASE I: Develop and demonstrate flight test modeling & simulation approach for a small generic UAV configuration recovering to a ship. Quantify the turn around time improvement and cost reduction versus fully coupled methods. Quantify resulting aircraft performance prediction fidelity versus fully coupled CFD methods

PHASE II: Improve phase I methodology to incorporate flight controls, autonomous controller, and other aircraft systems that affects UAV performance in the near-ship environment. Perform a simulated operational flight test for to-be-determined (TBD) UAV configuration for recovery to a TBD US Navy ship. Quantify the turn around time improvement versus currently available methods and resulting fidelity versus traditional and/or current methods.

PHASE III: The product will be transitioned to PMA 263 for UAV flight test support and system evaluation. The product will also be applicable to manned aircraft development programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Many aircraft companies, both small and large, are developing UAVs for military and commercial applications. This product will significantly improve commercial development of UAV systems through improved modeling and simulation of the UAV aerodynamics in challenging aerodynamic environments.

REFERENCES:
1. Syms, G., and Zan, S.J., “Analysis of Rotor Forces in a Ship Airwake”, AGARD-CP-552, “Aerodynamics and Aeroacoustics of Rotorcraft”, 75th AGARD FDP Meeting, Berlin, Germany, October 1994, paper no.31.

2. Polsky, S.A., and Bruner, C.W.S., “Time-Accurate Computational Simulations of an LHA Ship Airwake”, AIAA-2000-4126, presented at the 18th AIAA Applied Aerodynamics Conference, Denver, Colorado, 14-17 August 2000.

3. Landsberg, A.M., J.P. Boris, W. Sandberg, and T.R. Young, Jr., “Analysis of the Nonlinear Coupling Effects of a Helicopter Downwash with an Unsteady Ship Airwake.”, AIAA Paper 95 0047, Washington, DC, January 1995.

4. Polsky, S. and Naylor, S., “CVN Airwake Modeling and Integration: Initial Steps in the Creation and Implementation of a Virtual Burble for F-18 Carrier Landing Simulations”, AIAA Paper 2005-629, Aug. 2005

5. Woodson, S. and Ghee, T., "A Computational and Experimental Determination of the Air Flow Around the Landing Deck of a US Navy Destroyer (DDG)", AIAA Paper 2005-4958, June 2005.

KEYWORDS: Aerodynamic; Dynamic Interface; Modeling; Simulation; Uninhabited Air Vehicle (UAV); Airwake

N07-T005 TITLE: <u>Automated Texture Synthesis from Multi-spectral Satellite Imagery</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PMA-205 (Aviation Training Systems); P-3; Multi-Mission Maritime Aircraft

OBJECTIVE: Develop a system to generate fully synthetic textures from satellite photo-imagery in order to achieve both high and uniform realism in flight simulators

DESCRIPTION: In a flight simulator, imagery is dynamically viewed from a range of a few feet to tens of thousands of feet, and from highly oblique angles. While satellite imagery of real-world terrain is increasingly available in varying resolutions, spectral bands, and geographic coverage, even the best commercial satellite imagery (maximum resolution and quality) has definite limitations for use in simulation databases. For example, the 2-D satellite imagery of a certain terrain may be incompatible (mismatched in sharpness and placement) with synthetic 3-D features that sit on top of the terrain.

Present simulators, which are heavily dependent on satellite imagery products, cannot affordably provide unrestricted, world-wide flight training without significant variations in realism. In a typical simulator, the trainee witnesses widely differing and constantly changing levels of fidelity. In such systems, training effectiveness is compromised since the suspension of disbelief cannot be fully maintained. Also, in low altitude flight regimes, training cues are lost due to distorted and pixilated satellite texture and poor integration of the satellite textures with 3-D structures on the terrain surface. The use of micro-texturing and filtering techniques have been only partially effective and result in other unwanted artifacts.

Satellite photo-textures are very realistic when viewed from a sufficient distance. At closer distances realism decreases rapidly and distractingly. The Navy is seeking the development of an advanced system with the capability to seamlessly and dynamically integrate photo-textures derived from satellite imagery with fully synthetic terrain and 3-D feature textures for use in flight simulators. Proposed concepts should allow complete run-time control over lighting, shading, modulation, and seasonal changes. It is necessary for the developed system to control the integration of the satellite textures with the synthetic 3-D terrain and textures (transition/blending and substitution). This could possibly be performed as a function of the resolution of the photo-textures used in the simulator database, and the elevation, attitude, and velocity of the simulated aircraft. The proposed system should minimize the amount of manual pre-processing of synthetic textures, the need for large amounts of expensive high-resolution imagery to achieve consistent appearance, and the on-line disk space to store and retrieve photo-based textures.

PHASE I: Propose innovations based upon the advances in texture synthesis and related image rendering science, and identify how and where the feasibility of such innovations could best be demonstrated in existing flight simulators. Propose several Phase II evaluations of the new visual rendering system under varied sensor conditions.

PHASE II: Develop, integrate, and demonstrate a prototype system that assimilates recently acquired satellite data from multiple sensor types. Conduct the evaluations proposed in Phase I to assess the benefits of the new visual rendering under several sensor conditions.

PHASE III: Commercialize the system and apply to a complex training simulator.

PRIVATE SECTOR COMMERCIAL POTENTIAL DUAL/USE APPLICATIONS: The developed technology can be applied to commercial flight simulators and entertainment markets. It has application to fixed and rotary wing aircraft, unmanned aircraft, and any simulated entity that has highly dynamic motion on and above a real-world terrain area.

REFERENCES:
1. Glandville R., Texture Bombing, GPU Gems, Addison-Wesley, Reading, MA, 2004.

2. Hertzmann A., Jacobs C., Oliver N., Curless B., Salesin D., Image Analogies, SIGGRAPH 2001 Proceedings, Los Angeles, CA, 2001.

3. Wei, L., Tile-Based Texture Mapping, GPU Gems 2, Addison-Wesley, Reading, MA, 2005.

KEYWORDS: Visual Databases; Satellite Imagery; Texture Synthesis; Training Systems; Simulation Training; Sensor Fusion

N07-T006 TITLE: Algorithms for Digital Wideband Receiver Design/Analysis for Electronic Attack

TECHNOLOGY AREAS: Air Platform, Electronics, Weapons

ACQUISITION PROGRAM: PMA-234 EA-6B / PMA-265 EA-18G Program

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop an Electronic Attack (EA) Receiver Design/Analysis Algorithms which lead to design tools to perform rapid design and evaluation of proposed digital and microwave receivers for Electronic Attack using a standard PC. The final product will lead to design tools capable of designing a complete digital microwave receiver system for Electronic Attack through simulation using existing hardware models.

DESCRIPTION: Receiver technology is a critical component of today's Electronic Attack (EA) systems. Current airborne tactical jamming systems require rapid detection, geo-location, analysis and classification of emitters to support effective tactical jamming. In addition, emerging threat technologies such as spread spectrum, Ultra Wideband, and digital communication and radar systems require increased receiver capability.

To stay ahead of the enemy's technology such as the digital Radar, IED, etc. it is necessary to be able to:
(1) Rapidly design a digital microwave receiver
(2) Evaluate digital microwave receiver characteristic and architectures
(3) Predict the performance of a digital microwave receiver.
To be able to achieve all these, it is imperative to develop the proper algorithm which will enable the development of the proper design tools.

To support the design and evaluation of the required Electronic Attack Receivers, an algorithm that will lead to the development of a PC-Based software tool is sought that provides:
(1) The ability to rapidly design a digital microwave receiver from a graphical standard "tool set" of RF, microwave, digital, and digital signal processing components. Including
    a) Instantaneous Frequency Measurement (IFM)
    b) Spurious and harmonic mapping
    c) Phase interferometer and amplitude DOA/AOA arrays
    d) Pulse measurement
    e) Cueing
    f) RF, microwave, and digital receiver components
    g) FFT, Wavelet analysis, etc.
    h) Filters, mixers, combiners, amplifiers, and detectors.
(2) Evaluate performance and characteristics of entered digital receiver architectures and designs
(3) Simulate the operation of the digital receiver system and provide prediction of performance including
    a) Sensitivity
    b) Dynamic Range
    c) DOA / Geo-location
    d) Emitter classification
    e) Parameter measurement
(4) Emitter simulation library
    a) Communication type emitters
    b) Radar emitters

To be able to achieve all these, it is necessary to have the proper technology (algorithms). The hardware component models and basic RF analysis tools have been fairly mature but the proper integrated tool package to accomplish the described goal is still not available.

PHASE I: Establish the practicality of developing an EA receiver design/analysis tool. Identify the shortfalls that exist in analysis of receivers, and the advantages of being able to prototype receiver designs. Show how the analysis tool can result in rapid replication of receiver functionality and ease in fault identification and design changes.

PHASE II: Perform studies and analysis to develop the framework for the required EA Receiver Design/Analysis, identifying the key algorithms required and documenting these in a final report. A demonstration of the key software algorithms to demonstrate proof-of-concept is also required.

PHASE III: Develop, demonstrate, and validate a prototype EA Receiver Design/Analysis Tool. The demonstration should include validating the prototype capability by actual comparison of the prototype using the design of an existing microwave receiver such as ALQ-218.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The tool, as a generalized receiver analysis and design tool has potential to improve design productivity for military and commercial receivers including: cell phones, broadcast, GPS, data links, and wireless networks.

REFERENCES:
1. Jeruchhim, M. C., Balaban, P., and Shanmugan, K. S. “Simulation of Communication Systems”, New York, NY: Plenum Publishing, 1992.

2. Tsui, J. B. Y. “Microwave Receiver with Electronic Warfare Applications”, New York, NY:John Wiley & Sons, 2005.

3. Boyd, J. A. , Harris, D. B., King, D. D., and Welch, H. W., Jr.,Editors. “Electronic Countermeasures”, Los Altos, CA: Peninsula Publishing, 1978.

4. Tsui, J. B. Y. “Digital Techniques for Wideband Receivers” Raleigh, NC:SciTech Publishing Inc. 2004.

KEYWORDS: Electronic Attack, Electronic Warfare, Digital Receiver, Instantaneous Frequency Measurement, Microwave

N07-T007 TITLE: Precision Stabilization of a Ball Joint Gimbaled (BJG) Mirror

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

ACQUISITION PROGRAM: PMA-263 UAV Office

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a low cost, precision, dynamic measurement/steering system for a ball joint gimbal mirror for use in a broad family of electo-optic/infrared/laser radar/millimeter wave (EO/IR/LADAR/MMW) sensors.

DESCRIPTION: Currently half the cost of high performance EO/IR/LADAR/MMW systems is due to the mechanical gimbal system used to point and stabilize the field of vision (FOV) of high resolution (typically few tenths of a milliradian) sensors. One alternative to multi-axis mechanical gimbal systems investigated by NAVAIR is the use of a Ball Joint Gimbal (BJG) mirror system. The existing BJG system consists of a mirror mounted on a ball joint gimbal (BJG) which is rapidly controlled using a set (typically 4) of Kevlar control lines. This device has been effective as a means to point and stabilize lower resolution (hundredths of a milliradian) sensors. The current control system relies on precise measurements of the Kevlar line lengths and feedback loops to keep the mirror position within acceptable bounds. The current challenge is to find a low cost innovative approach to precision pointing and tracking for higher resolution sensors. Recent studies have indicated that the current system indeed will not meet the required performance parameters for higher resolution sensors since the Kevlar lines actually stretch under the stresses of high speed mirror control.

It is suspected that the required performance can be achieved by a feedback loop based on precise measurements of the actual mirror position. The goal of this STTR is to develop an innovative low-cost, reliable measurement/steering system for the ball joint gimbal mirror so it can stabilize and point high resolution IR/EO/LADAR/MMW sensors. Proposed approaches must reliably demonstrate the following: steering/measurement precision to less than a millionth of an inch; dynamic steering of the mirror several degrees per millisecond. The capability of the system will be demonstrated under a wide range of temperatures, vibrations, and shock conditions.

PHASE I: Demonstrate feasibility of proposed approaches through modeling efforts in order to demonstrate the ability to provide the necessary levels of performance (speed, accuracy, reproducibility).

PHASE II: Develop and integrate a prototype measurement system with a ball joint gimbal (BJG) system provided by NAVAIR. Demonstrate the required levels of performance through substantial testing under a wide range of temperatures, vibrations, and shock conditions.

PHASE III: Validate the performance of the innovation through flight testing on a to-be-determined platform of interest. Transition the technology to an existing platform.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Current multi-axis mechanical gimbal systems are significant cost drivers among large families of airborne EO/IR/LADAR systems employed for urban mapping, traffic monitoring, surveillance, collision avoidance, and news reporting (when they switch to HD TV). All of these systems would benefit from the reduced gimbal costs (roughly a factor of 5) this approach can provide.

KEYWORDS: Ball Joint Gimbal; Optical Stabilization; High Resolution; High Accuracy; Electo-Optic/Infra-Red/Laser-Radar (EO/IR/LADAR); Low Cost Gimbal

N07-T008 TITLE: Advanced Eddy Current Braking Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PMA-251: C13-2 Catapult System

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate an eddy current brake capable of stopping a catapult aboard aircraft carriers.

DESCRIPTION: Naval aviation is dependant on the ability to launch aircraft expeditiously and safely aboard ship. The steam catapult system performs this task currently and will continue to do so for the next 50 years. A significant maintenance driver in the catapult system is the current water brake sub-system. This device brakes the catapult piston assembly post aircraft separation. These pistons enter a fluid filled chamber and braking occurs. The Navy is interested in replacing the water brake with a permanent magnet eddy current brake. Permanent magnets are attractive due to their lack of moving parts, which should translate to a significant decrease in maintenance cost.

Currently eddy current technology is capable of stopping approximately 10,000 pounds traveling at a maximum speed of 60-65 mph. This is according to sources in the roller coaster industry. To meet the needs of the Navy, this technology needs to be advanced to handle speeds routinely approaching 180 knots. The weight however, will be reduced from current usage of the technology to around 5,000 pounds. Stopping distances on the other hand will likely be much shorter, near 18 feet (30 foot maximum). Stopping distances of the current systems is unknown at this time.

The eddy current brake system has no moving parts or power requirements in such a design. Therefore there will be very little to no maintenance required. Currently the water brakes are one of the most expensive, manpower consuming, and often downed parts of the catapult.

Using the eddy current brake system design, the Navy is looking for concepts to minimize the number of moving parts and minimize impact to ship systems (e.g. do not require ship's power, will fit in existing water brake spaces) will be given higher consideration. Proposals that address certain aspects of this problem, such as research into higher performing materials, will be considered.

PHASE I: Determine the feasibility of developing an eddy current braking concept as described above. Prove, through analysis, models and/or lab demonstration, that the concept(s) could meet the stated requirements. The assessment should include a high-level assessment of cost, maintainability and producability. Identify key technology risk areas, such as high technological risk components, manufacturing processes, etc. that represent the key technical hurdles to the concept's successful development. Identify commercial applications that could benefit from this technology.

PHASE II: Produce prototypes and reduce technical risk for success by addressing the key technology areas identified in Phase I. Complete a thorough design of the concept, including electromagnetic, electrical, mechanical, and thermal analyses that support a viable design concept.

PHASE III: Produce a full-scale system for land-based testing at the C13-2 catapult test site at the Naval Air Systems Command Lakehurst. Perform performance testing at full scale with deadloads and live aircraft, and conduct shock and vibration testing. A successful system could be integrated into C13 catapults aboard existing carriers.

PRIVATE SECTOR COMMERCIAL POTENTIAL: An eddy current braking system could benefit a wide range of applications, including high-speed trains, elevators, electric vehicles, and G-force simulators.

REFERENCES:
1. A.E. Fitzgerald, et al, Electric Machinery (6th edition), McGraw-Hill, 2003

2. R. Parker, Advances in Permanent Magnetism, John Wiley, 1990

3. Water Brake Design Envelope, to be posted on SITIS web site, http://dodsbir.net/sitis/default.asp

KEYWORDS: Eddy current; Permanent magnet; High-speed braking; Energy absorption; Carrier aircraft launch

N07-T009 TITLE: High Energy, Low Loss Fibers for Ultra Short Pulse Laser Compression and Delivery

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: PMA-290/PMA-281/PMS-405, Directed Energy Office. ACAT III

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate a fiber capable of handling high energy ultra short pulses. The fibers should be usable for compression and/or delivery applications.

DESCRIPTION: Ultra Short Pulse (USP) Lasers offer a variety of potential applications of interest to the Navy in the fields of sensing, diagnostics, distance interrogation, and weapons potential. At energy levels of interest the current state of the art of USP lasers only provides for freespace delivery, greatly restricting the practicality and deployability of USP laser based applications.

The Navy is interested in the development of low loss fibers that can be integrated into existing high energy USP laser technologies to create a scalable, flexible, compact system. Such systems would enable numerous applications in the USP laser field and allow for easier integration into existing sea and air based platforms. Current state of the art photonic crystal fiber technology used for fiber delivery and/or compression of ultrashort pulses is typically limited by nonlinearities to nanojoule energy levels. In order to improve this performance and enable new applications, it will be necessary to design and fabricate new optical fibers and waveguides with low nonlinearities and adequate dispersion values. Due to the early nature of this technology, research will be necessary to identify successful designs and define an effective and efficient fabrication process. Proposed methods will lead to the development of optical waveguides such as hollow core fibers that can be utilized for USP laser compression and/or delivery. The resulting fiber and/or waveguides should be suitable for refinement and integration into existing ultra short pulse laser systems, and culminate in an all-fiber ultra short pulse laser system (<1ps) capable of ablative energy levels (>10µJ) and high (>100 kHz) repetition rates around the eye-safe wavelength of 1550 nm. Small businesses and universities responding to this solicitation are strongly encouraged to have previously demonstrated expertise in the area of ultra-short pulse fiber compression and delivery for pulse energy greater than 1 µJ per pulse.

PHASE I: Demonstrate concept feasibility using a computer model to validate the design and scalability for a photonic band gap hollow core fiber used to achieve the performance requirements of high energy pulse compression and/or fiber delivery. Identify possible fiber fabrication techniques to be evaluated in Phase II.

PHASE II: Compare proposed fiber fabrication techniques from Phase I and select the most effective method. Fabricate a prototype waveguide component and demonstrate its performance. Demonstrate waveguide-based pulse compression and fiber delivery of high energy pulses in a small (20 centimeter diameter) footprint.

PHASE III: Continue to demonstrate improved results in compression and delivery of high energy pulses in a reduced footprint. Improve the manufacturing process and explore volume manufacturing techniques. Perform the integration of the waveguide component into an all-fiber ultra short pulse laser system. Explore potential applications of the all-fiber ultra short pulse laser system in Navy platforms of interest.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
The availability of high energy fiber optics will allow for a multitude of USP laser based diagnostic and ablative applications in the fields of medicine, precision machining of metals and composites, and other manufacturing techniques.

REFERENCES:
1. Torkel D. Engeness, Mihai Ibanescu, Steven G. Johnson, Ori Weisberg, Maksim Skorobogatiy, Steven Jacobs, and Yoel Fink, " Dispersion tailoring and compensation by modal interactions in OmniGuide fibers," Optics Express, Vol. 11, No. 10, pp. 1175-1196, 2003.

2. Sonali Dasgupta, Bishnu P. Pal, and M. R. Shenoy, "Design of dispersion-compensating Bragg fiber with an ultrahigh figure of merit," Optics Letters, Vol. 30, No. 15, pp. 1917-1919, 2005.

3. Steven G. Johnson, Mihai Ibanescu, M. Skorobogatiy, Ori Weisberg, Torkel D. Ingeness, Marin Soljacic, Steven A. Jacobs, J. D. Joannopoulos, and Yoel Fink, "Low-loss asymptotically single-mode propagation in large-core OmniGuide fibers," Vol. 9, No. 13, pp. 748-779, 2001.

KEYWORDS: Fiber delivery; Pulse compression; Ultra-short pulse; Compact fiber laser system

N07-T010 TITLE: <u>Physics Based Gear Health Prognosis via Modeling Coupled with Component Level Tests</u>

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: AIR 4.4, JSF, H-60, H-53, H-1, VH-71

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OBJECTIVE: Develop physics based gear health prognosis models for tooth bending fatigue, pitting and spalling failure modes. Refine the physics based models based on failure data collected from component level gear tests. Validate via demonstration tests the capability of the developed models to accurately quantify the current state and to predict the remaining useful life of the modeled components.

DESCRIPTION: The algorithms that are currently employed for determining gear health are primarily empirically derived from health monitoring sensor data obtained from system or subsystem component tests or in-service failures. These algorithms mainly rely on rotational speed and tooth meshing frequencies, or are statistical in nature. The physics based models of gear faults developed under this topic should include tooth-bending fatigue, pitting and spalling failure modes. The physics based models should account for specific characteristics of the gears being modeled including geometry, alloy composition and materials characteristics, case and core hardnesses, case depth, ratio of case thickness to tooth thickness, surface finish and machining characteristics. These models must be able to be updated via sensor feedback from operating gear tests. Test to failure of the modeled gears is required in order to refine the models, to demonstrate the ability to calibrate the models via sensor feedback, and to validate the ability of the models to accurately quantify the current health state and predict remaining useful life.

PHASE I: Demonstrate feasibility of physics based gear health models to quantify tooth bending fatigue, pitting and spalling failure modes. Develop and demonstrate proof of concept models and associated state awareness sensors that are capable of making the required health assessments of gear health.

PHASE II: Refine the models for accuracy by accounting for geometry, alloy composition and materials characteristics, case and core hardnesses, case depth, ratio of case thickness to tooth thickness, surface finish and machining characteristics. Validate via demonstration tests the capability of the developed models to accurately quantify the current state and to predict the remaining useful life of the modeled components.

PHASE III: Finalize the physics based gear health prognosis models with major DoD end users, airframe. and engine manufacturers and conduct necessary qualification testing for the applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The physics based gear health prognosis models developed under this topic would significantly enhance the state of the art for commercial aviation. The technology is directly transferable to commercial gearbox applications.

REFERENCES:
1. A Survey of Data-Driven Prognostics. http://ti.arc.nasa.gov/people/schwabac/AIAA-39300-874.pdf.

2. Advanced Vibration Analysis to Support Prognosis of Rotating Machinery Components. http://www.impact-tek.com/Data/Publications/ Vib_Inst_2005_Rotating%20Machinery%20Components.pdf.

KEYWORDS: Gear; Prognosis; Models; Health; Pitting; Spalling; Fatigue

N07-T011 TITLE: <u>Inlet Design and Performance for Supersonic Cruise/Hypersonic Operation Vehicles</u>

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: NAVAIR 4.4 Propulsion & Power

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Define new approaches to the design and performance analysis of inlet components for very high-speed vehicles for supersonic cruise (Mach 2 to 4+) and hypersonic operation (up to Mach 5+). Analysis may be done by employing current state-of-the-art computational fluid dynamics (CFD) modeling and simulation methodologies.

DESCRIPTION: New innovative approaches are sought to design and engineer inlet components for very high-speed vehicles. Proposed air inlet designs should be optimized for supersonic cruise and hypersonic dash operation. Supersonic cruise inlet design emphasis is on minimizing drag at their particular supersonic design point. To that extent, they feature reduced cowl lip thickness, boundary layer bleeds and sophisticated bypass systems for stable operation. Design optimization is a function of the Mach number: as Mach number increases, lip cowl drag is more important while bleed, spillage drag and bypass flow are emphasized less. For Mach numbers in the 4-6 range, the emphasis is on achieving low off-design drag and flow matching for stability (unstart-free) and integration of the variable cycle powerplants. Efficient integration of the inlet with airframe is also critical in this speed regime and the optimization of the inlet design can be achieved both at the component and system level.

CFD methodologies for the design and performance analysis of very high-speed inlets should be able to accurately simulate the physics of strong shock interactions, incident oblique shocks, compression corners and shock expansions. They also should be able to model multiple air injection paths to control shockwave-boundary layer interaction, as well as complex flow spillages.

PHASE I: Demonstrate the feasibility of proposed CFD methodologies for inlet performance analysis. Of primary interest are the accuracy of the simulations compared to experimental data, as well as the practicality of the simulations in terms of turn-around times. Applicability of these methodologies in the design process for high-speed inlets will also need to be demonstrated.

PHASE II: Develop design procedures employing Phase I methodologies. Further improve selected methodologies so that they can be employed/validated in prototype demonstration. Demonstrate accurate performance analysis of very high-speed inlets with quick turn-around times.

PHASE III: Transition the technology to ongoing DoD programs. Demonstrate that the transition of this innovation leads to significant cost savings in the design of very high-speed air vehicles by major airframe DoD contractors.

PRIVATE SECTOR COMMERCIAL POTENITAL/DUAL-USE APPLICATIONS:
Successful development of the improved CFD methodologies for high-speed inlets should enable design engineers to select new and innovative concepts that optimize inlet performance and to integrate these designs in future high-speed air vehicles in a very cost-efficient manner.

REFERENCES:
1. AGARD Fluid Dynamics Panel Working Group 13, “Air Intakes for High Speed Vehicles,” AGARD AR-270, Sept. 1991. (and references therein)

2. Tjonneland, E., "The Design, Development and Testing of a Supersonic Transport Inlet System," AGARD CP 91-71, Sept. 1991.

3. Smith, C.F., and Smith, G. E., Two Stage Supersonic Inlet (TSSI): 10-inch Model Calculations, NASA/CR-2005-213287, January 2005.

KEYWORDS: Propulsion/Airframe Integration; Supersonic/Hypersonic Air Vehicles; Computational Fluid Dynamics; Versatile Affordable Advanced Turbine Engines (VAATE) Program; High-Speed Propulsion; Missiles

N07-T012 TITLE: Innovative Approaches For Light Weight Optically Transparent Energy Dispersing Composite Structural Windscreens

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate effective low-cost approaches for simultaneously reducing the weight and increasing the structural performance of optically transparent windscreens.

DESCRIPTION: Military aircraft are constantly being targeted for weight reduction. An innovative light weight high strength composite windshield is sought. Proposed windshield concepts would need to be able to withstand high speed impacts such as the impact of a 3-4 lb bird at velocities of up to 300 kts, or a power transmission cable impacting a helicopter canopy during high speed forward flight. The windshield itself will need to be able to disperse the energy of the impact such that the resulting load imparted to the surrounding support structure is equal or less than current windshields. Currently, windscreen components are comprised of multiple transparency sections held in place by structural joining members. The joining members are required since existing transparency components are considered non-structural. Development of a windshield exhibiting structural characteristics that would not require some or all of the structural joining members would be desirable. Proposed concepts would be required to exhibit optical qualities equivalent to existing materials, not allow for any increase in load to be imparted onto surrounding aircraft structure under normal design conditions and show a reduction in weight compared to conventional windshields. Finally the windscreen will need to show equal or greater resistance to abrasion and basic impact damage due to use in austere environments.

PHASE I: Develop efficient low-cost approaches for improving the structural performance of windscreen components, enabling higher energy absorption/impact capabilities and possibly a reduction in joining members, without an increase in weight. Demonstrate the feasibility of the proposed concept through coupon fabrication and testing of critical properties.

PHASE II: Perform mechanical testing to determine required properties for development of an analytical tool. This analytical tool will need to provide an accurate prediction of the load transfer from the windshield to the surrounding structure under dynamic loading conditions such as the ones listed in sections above. Develop the detailed design of a prototype windscreen. The prototype windshield will need to demonstrate the capability to be formed into complex shapes, while maintaining optical quality. (Most military windscreens are not flat panels.) Perform detailed structural analysis to assess the ability of the design to carry the component design loads. Fabricate a full-scale prototype windscreen and perform required performance testing.

PHASE III: Develop a manufacturing plan and transition the design to military and/or commercial aircraft. This transition will need to incorporate the non-structural of a windshield, such as but not limited to, glare reduction, radiation coating, and defog capabilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
Improved structural windscreens can transition to the commercial aircraft industry enabling weight reductions along with improved viewing area.

REFERENCES:
1. K.D. Weaver, J.O. Stoffer, D.E. Day, “Preparation of Transparent Glass Reinforced PMMA Matrix Composites,” Polymeric Mat. Sci. and Eng., 65, 221-222 (1991).

2. T.W.H. Wang, F.D. Blum, L.R. Dharani, "Effect of interfacial mobility on flexural strength and fracture toughness of glass/epoxy laminates," J. Mat. Sci., 34[19], 4873-4882 (1999).

3. S. Kang, H. Lin, D.E. Day, "Optically Transparent Poly(Methyl Methacrylate) Composites made with Glass Fibers of Varying Refractive Index," J. Mat. Research, 12[4] 1091-1101 (1997).

KEYWORDS: transparencies; windshield; windscreen; composite windshield; bird strike; cable strike; high strength windshield

N07-T013 TITLE: Compact Pulse Generator

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PMA-251 – Electromagnetic Aircraft Launch System

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate a high power (60 MegaWatt [MW]), compact pulse generator.

DESCRIPTION: The Navy is currently investigating electrical and electromagnetic technologies for a variety of naval applications, from elevators to aircraft launchers to ship propulsion to aircraft weapon systems. Critical to all these applications is the generation of large amounts of electrical power. Most of these naval applications will rely on pulsed power, the development of large pulses of electrical power for a short time duration. Commercial power generators are large and bulky, making them prohibitive for use on a naval ship and most are continuous duty machines.

There exists a need to develop an innovative compact, high power generator technology to enable or improve some of these electrical systems. An example is the new aircraft launch system for launching aircraft from a ship. This launch system requires a significant pulse, approximately 2 seconds, of electrical power to provide the accelerating force to the aircraft. And while the generators developed for this system fit on the ship, they are still larger and heavier than an advanced compact, high power generator could be.

A new pulse generator that is compact and lightweight would prove especially valuable to ease ship integration issues. The pulsed electrical power required would be approximately 60 MW/60MJ in the kilovolt range. Densities should be in the range of 15 kJ/kg and 12 kW/kg, which in some cases is an order of magnitude improvement over commercial systems. A compact pulse generator meeting these criteria would significantly surpass the current state-of-the-art and provide significant savings to the Navy by reducing the ship's weight and center of gravity, making the ship more stable and buying back service life allowance. In addition, the commercial benefits of a successful demonstration of this technology are quite large, from electric vehicles to reserve emergency power for critical electrical systems.

PHASE I: Conduct an investigation to determine the feasibility of developing a compact pulse generator described above. Prove, through analysis, models and/or lab demonstration, that the concept(s) could meet the stated requirements. The assessment should include a high-level assessment of cost and produceability. Identify key technology areas, such as high technological risk components, manufacturing processes, etc. that represent the key technical hurdles to the concept's successful development. Identify commercial applications that could benefit from this technology.

PHASE II: Produce prototypes and successfully demonstrate the key technology areas identified in Phase I, thereby significantly reducing the technical risk for successful development of the concept. Complete a thorough design of the concept, including electromagnetic, electrical, mechanical, and thermal analysis that supports a viable design concept.

PHASE III: Produce a full-scale system for land-based testing at the Electro-Magnetic Aircraft Launch System (EMALS) test site at the Naval Air Systems Command Lakehurst. A successful system could be integrated into

EMALS aboard future carriers. Utilize first articles to demonstrate benefits for commercial applications, such as electric vehicles, Uninterruptible Power Supplies, etc.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A compact pulse generator could benefit a wide range of applications, including electric vehicles, Directed Energy Weapons, High-Power Microwave, Self-Protection, Uninterruptible Power Supplies etc. The commercial electric vehicle and UPS market could utilize a compact, high power generator to relieve the weight and volume constraints of the present electric generator technology.

REFERENCES:
1. "Electromagnetic Aircraft Launch System (EMALS)", IEEE Transactions on Magnetics, January 1995, Volume 31, Number 1.

2. "The Benefits of Launching Aircraft Electromagnetically", Naval Engineers Journal, May 2000, Vol. 112, Number 3.

KEYWORDS: Pulse Generator; High Speed Machinery; Composites; Compact Pulse Generator; Power Generation; Power Generation Machinery

N07-T014 TITLE: Portable Interactive 3D Virtual Reality Training System

TECHNOLOGY AREAS: Electronics, Human Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop an innovative, compact, cost-effective 3D Virtual Reality (VR) Training System that could be easily transported and installed on-board a submarine, that can be used for tactical, control room training and competency certification and mission rehearsals. This 3D VR Trainer will be networked at the training site so that the students and instructor can see and communicate with each other and interact with real control room data. The technical challenge will be to provide a communications link with the security, speed and bandwidth necessary to link the trainer to remote Navy Laboratories that will be providing display and control system data output. These data will be generated by land-based full system simulation systems such as the Submarine Multi-Mission Team Trainer (SMTT) and will be live fed via satellite communication in near real-time.

The students will be equipped with head mounted displays and a control devices, such as laptop computers or hand-held controls, so that they can see combat system displays and interact with the data and control the response of the equipment that they are operating. The students’ movements and their interaction with the live fed data will be tracked and recorded in real-time. The instructor will be given the additional capability to guide and teach the students during the training. VR systems with motion tracking have primarily been used as standalone systems in training environments. The technical challenge will be to design a VR trainer that will accommodate multiple users, each with motion tracking devices and communication links to the VR training system, in other words develop multiple system interfaces that work simultaneously and well together. Adding to the problem on-board a submarine will be a complex physical environment that is not conducive to short range, RF communication. The 3D Virtual Reality Training System will provide improved training efficiency and rapid acquisition of expertise of operational skills in a very realistic shipboard-like environment.

DESCRIPTION: The training of submarine combat control parties are performed using physical mock-ups located at major submarine bases or on-board ships that are pier-side in a non-dynamic environment. With the redeployment of portions of the submarine fleet to more remote locations the training of submarine crews in specially designed, fully functional training facilities becomes a very major undertaking if new facilities are needed or logistically cumbersome and time-consuming if crews are transported to a major CONUS submarine base with the required training facilities.

With the advent of low-cost, high performance computers and the development of 3D Virtual Reality technologies including commercial high fidelity computer game signal processors and algorithms in such systems as Microsoft's Xbox 360® and Sony's Playstation 3® video game consoles, it becomes possible to create a simulated, shipboard environment in which the student is networked together with the instructor in an immersive, virtual-reality shipboard environment through the employment of computer peripherals, such as head mounted displays and motion tracking sensors. All the users would be able to see and communicate with each other and interact with live or simulated data. The instructor would be given additional control to guide and tutor the student while connected live. Additionally, the training exercise can be linked to land-based training simulators such as the Common Basic Operator Trainer (CBOT) or the Submarine Multi-Mission Team Trainer (SMMTT), to create a dynamic, simulated real-world operational environment. The major challenges in the 3D VR Training System are the development of a system that will network a team of students and instructors on-board the submarine, developing two-way communication interfaces and links that will provide high fidelity, secure, live feed, combat display data to the students and instructors, while embedding them in a virtual real-world environment and providing the instructors the capability of interacting with the data and students to better train them for their individual combat control duties.

PHASE I: Determine the feasibility of developing a Cost-Effective, Portable Interactive 3D Virtual Reality Training System, develop the design concept and demonstrate proof-of-concept.

PHASE II: Develop a prototype Cost-Effective, Portable Interactive Training System including hardware and software, designed to be easily transported to and installed on-board a submarine. The training system will be designed to link and track students wirelessly and to be linked via a communication link to land-based simulators such as the CBOT and SMMTT. Initial demonstration will be in a dry-land Navy facility.

PHASE III: Install the Portable Interactive 3D VR Training System on-board an operational submarine and demonstrate and test the full-system Portable Interactive Training System, with realistic training scenarios

PRIVATE SECTOR COMMERCIAL POTENTIAL: Portable Interactive 3D VR Training Systems have broad application in public-sector for firefighter training and chemical and biological threat response training. An affordable VR Interactive Trainer for firefighter training would address a large domestic commercial market need.

REFERENCES:
1. Tate, D.L. "Virtual Environments for Shipboard Firefighting Training," varais, p. 61, 1997 Virtual Reality Annual International Symposium (VRAIS '97), 1997.

2. F. Tendick, M. Downes, T. Goktekin, M.C. Cavusoglu, D. Feygin, X. Wu, R. Eyal, M. Hegarty, and L.W. Way, "A Virtual Environment Testbed for Training Laparoscopic Surgical Skills," Presence vol. 9, no. 3, pages 236-255, June 2000.

3. J. C. Chung, M. R. Harris, F. P. Brooks, Jr., H. Fuchs, M. T. Kelley, J. Hughes, M. Ouh- Young, C. Cheung, R. L. Holloway, and M. Pique, "Exploring Virtual Worlds with Head- Mounted Displays," Proceedings of the SPIE Conference on Three-Dimensional Visualization and Display Technologies, Los Angeles, January 18-20, 1990, pp. 42-52.

4. J. W. Regian, W. L. Shebilske, and J. M. Monk, "Virtual Reality: An Instructional Medium for Visual-Spatial Tasks," J. Communication , Vol. 42, , 1992, pp. 136- 149.

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KEYWORDS: Virtual; Reality; Submarine; Trainer; Computer; Simulation

N07-T015 TITLE: Software Integration Diagnostic and Predictive Tools

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PMS 501, Littoral Combat Ship (LCS), ACAT 1

OBJECTIVE: Develop a suite of software tools to assist in uncovering hazardous or malicious logic in application and infrastructure software.

DESCRIPTION: The development cycle for Navy ships from concept to construction is being reduced by 50%. Navy ships are employing a wider array of mission modules and open architectures, including software from foreign sources. Shorter timelines for integration of mission system software necessitate tools capable of rigorous and rapid scrutiny of software by ship integrators, with the goal of assuring secure and reliable behavior during operation. Tool(s) are needed to increase the integrators' confidence in the actions of the operational software, and improve productivity for what is now a labor intensive process. Techniques that can help an examiner find the trigger and/or the payload of malicious code are encouraged, as are methods that can address the special challenges posed by real-time systems. For example, one tool might analyze the software's behavior when given out-of-range values and/or erratic values as inputs, with the goal of assessing the error management capability of the artifact under investigation. The tool(s) must be capable of generating diagnostic, prognostic, and metric statistics. The approach should be applicable to application code and associated interfaces, to very large, highly complicated, multi-lingual, real-time programs, and should not require that the program be executed. The tool(s) should support information processing systems that have heterogeneous programming languages, different operating systems, dissimilar "software backplanes," alternative communications subsystems, and varied hardware

PHASE I: Define the requirement specifications for the suite of tools including defining tool functions, input / output parameters, and diagnostic, prognostic and metric statistics. Determine appropriate application and use of tools by software integrators.

PHASE II: Develop prototype suite of tools and demonstrate proof of concept on a test case, with evidence that scalability to 1M SLOC programs is feasible. Evaluate the soundness and precision of the approach. Develop a representative testing environment using existing DoD software.

PHASE III: Refine the suite of tools and continue evaluation in test environments. Develop a capability transition package that includes documented software, hardware and interface specifications, interactive training package, operable software, and user guides.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This capability has a broad range of potential for other federal, state government and private sector applications, including:
- Weapons system integration
- Large enterprise software integration
- Rapid integration of commercial software

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KEYWORDS: software integration; diagnostic; prognostic; malicious code; information assurance; verification and validation

N07-T016 TITLE: Miniaturized Wireless Data Acquisition for Payload Development and Integration

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Weapons

ACQUISITION PROGRAM: PMS 415, Undersea Defensive Warfare Systems, ACAT III

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a miniaturized wireless data acquisition system, survivable in impact launch environments. The data collected by this system will aid simulation verification efforts for existing/future submarine and surface ship payloads such as countermeasures, torpedoes, unmanned underwater vehicles, and other deployable systems.

DESCRIPTION: The U.S. Navy has a need to reliably and repeatedly acquire a variety of parameters related to the launch and deployment of submarine and surface payloads including torpedo decoys (countermeasures), torpedoes and other vehicles and payloads. These payloads are launched from a variety of launchers, including, but not limited to, external countermeasure launchers, surface vessel torpedo tubes, submarine torpedo tubes, and missile launchers. These launch events typically involve significant structural, hydrodynamic, hydrostatic, and cross-flow impact forces on the order of 100 g's and 100 feet-per-second (longitudinal) and up to 1000 g's (lateral). These environmental requirements are very challenging and risky, and multiple attempts to develop this type of system in the past have failed. The combination of launch physics, system form factor, and performance requirements will require a novel, R&D-intensive, and original solution.

The ability to acquire such parameters as acceleration, roll/pitch/yaw, bending strain, compressive loads, acceleration, velocity, displacement, highly dynamic hydrodynamic pressures, etc. during prototype testing and development is critical for a variety of reasons. They include: requirements definition, launch impulse mechanism design criteria and constraints, vehicle structural, performance and survivability requirements, safe separation requirements, and the gathering of high-fidelity data for the improvement and validation of the Navy's Simulation Based Design (SBD) tools in this area. This effort would lead to the manufacture of a self-contained, wireless data acquisition system small enough to fit in vehicles having an internal diameter of 2.85 inches. This system should consist of an embedded processor with multi-channel data acquisition card(s). The acquisition system should be capable of acquiring up to 16 channels at a minimum rate of 10 KHz per channel. Signal conditioning should have programmable gains to support a variety of sensors such as: accelerometers, pressure transducers, inertial measurement units, rate sensors, and strain gauges. It should be able communicate with a remote personal computer for both configuration (channel name, acquisition rates and duration, etc.) and data off-load (download). This should be done via wireless means, thus eliminating the need for a penetration in the payload and/or tear down of the payload, during initialization and data extraction. As a back up, the device would retain the data in memory or flash drive if the wireless capability fails. The system would be integrated into the test payloads in a manner to isolate the acquisition system from launch stresses. In addition, the unit must operate under its own power for several days, and must be able to trigger its data acquisition in such a way as to capture all data from the launch. The system must be able to go to “sleep” and also run at reduced speed to reduce power consumption and be triggered to fully operational mode via a remote personal computer.

PHASE I: Develop a design for a reconfigurable and wirelessly operated data acquisition system, including signal conditioning and power supply capabilities, taking into account the requirements described above. This would include the design of the user/programmer interface using LabVIEW Embedded Development System.

PHASE II: Build and test a prototype acquisition system in a representative environment to prove it is suitable. Conduct a prototype demonstration to demonstrate system robustness (vibration, acceleration survivability). Develop and demonstrate the system reconfiguration and management software.

PHASE III: Prepare final acquisition design and user packages. Integrate and test the system with a Navy-provided payload. Standardize the design and produce it for use by military and civilian activities needed self-contain processor and data acquisition solutions.

PRIVATE SECTOR COMMERCIAL POTENTIAL DUAL/USE APPLICATIONS: This system could be used in any remote application where data collection is required in severe environments and wireless data acquisition/download of data is required. This could be used in the power industry, oil and gas production industries, civilian remotely-operated vehicles, oceanography, meteorology (collecting data during hurricanes, tornadoes, etc.) providing data access and sharing to remote sites, cell phones and Personal Data Assistants, etc.

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KEYWORDS: data; acquisition; payload; countermeasure; miniature; wireless, submarine, launch

N07-T017 TITLE: Optical Communications for ASW and MIW Applications

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: PMA 264, PMS 485, PEO IWS and PEO LMW

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop novel free-space Optical Communications (OCOMM’s) systems and/or signal processing techniques to significantly extend the time-bandwidth product associated with point-to-point, point to multipoint, and underwater network communications. To extend the range performance of optical communications systems beyond current nominal limits particularly in turbid littoral waters. To create designs that adapt to sub-optimal underwater environments in order to minimize energy cost per byte of information transmitted. To provide a modular electrical and mechanical interface capable of interfacing with a wide variety of platforms and system architectures. To develop interfaces that are protocol independent whenever feasible. To evaluate the utility of such a communication system when used for Anti-Submarine Warfare (ASW), particularly in distributed surveillance systems, and in Mine Warfare (MIW) missions.

DESCRIPTION: The use of Acoustic Communications (ACOMM’s) is the defacto standard when underwater communication channels are required. However, ACOMM systems have significant limitations with respect to data rate and covertness. The possible advantages of using an OCOMM in some situations is significant and has the potential of vastly improving the performance of several ASW and MIW concepts currently under consideration. The Secretary of the Navy's Naval Transformation Roadmap/Sea Power 21 Vision - "Transformational efforts in ASW are focused on developing new operational concepts that leverage advanced technologies to improve wide-area surveillance, detection, localization, tracking and attack capabilities against quiet adversary submarines operating in a noisy and cluttered shallow water environment". Many of these transformational concepts require a significant communication backbone in order to be effective. At the extremes, there are two nominal approaches to meeting this vision; provide more capable sensor nodes having significant organic autonomous signal processing capabilities (tera-op processing power) or provide broadband communication channels of sufficient bandwith to handle raw sensor data (tens to hundreds of megabytes per second). The best and most feasible solutions are expected to be a hybrid, falling somewhere between these two extremes. Developing and fielding enhanced communications capabilities such as those possible with OCOMM systems provides significant payoff to Navy defense mission applications. These include enhanced submarine and surface ship detection and tracking, mine hunting (including in the beach/surf zone), weapons detection, underwater surveillance carried out by unmanned vehicles, and ground incursion systems. Ultimately, tradeoffs must be made between performance enhancements that can gain by improving communications and those that can be gained though enhanced sensors and signal processing. All OCOMM technologies will be considered but those offering traits consistent with those identified in the objective above will be favored.

The Navy will only fund proposals that are truly innovative and involve technical risk. Proposals must address both S&T and R&D aspects of the OCOMM system.

PHASE I: Research an approach that demonstrates scientific merit and capabilities of the proposed OCOMM system and/or signal processing techniques. Specific areas of interest include bandwidth, range performance, power consumption and cost.

PHASE II: Build and characterize prototype OCOMM system and/or signal processing techniques. In this phase the prototype need not be fully compatible with all ASW or MIW platforms, but a clear and short development trail must be established to show how full compatibility could be achieved.

PHASE III: Develop and deliver the OCOMM system for use in MIW or ASW applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Free-space OCOMM systems are presently used commercially for terrestrial applications evolving point-to-point, high bandwidth applications. These include: LAN extensions, point-to-point secure communication links, and, low impact data links between remote site locations. Development of robust OCOMM capabilities for underwater vehicles could greatly enhance their effectiveness by obviating some of the excessive signal processing need for autonomy. This in turn reduces power consumption, which increases platform endurance.

KEYWORDS: Photonics, Optics, Communications, Free-Space, OCOMM, signal processing

N07-T018   TITLE: <u>Manufacturable bump bonding technologies for high speed, low volume technologies</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Radio Frequency Antennas & Topside Program Manager, code PMW 180-D4/E2

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OBJECTIVE: Develop automatable techniques for mounting for test, then permanently bonding multiple chips which pass signals at >20 GHz.

DESCRIPTION: Several immature digital technologies based on both compound semiconductors and superconductors are currently experimenting with circuit chips clocking at 10-80 GHz. Functionality in larger, more complex circuits needs to be demonstrated before the fabrication technologies are matured to the point where such entire systems can be built on a single chip. This is best accomplished through the use of multi-chip modules that can allow multiple chips to communicate with one another at full clock speed and with low cross-talk. In this case, it is essential to be able to test all die before assembly and to be able to rework the modules after final testing. Solder bumps have been demonstrate to work in this way up to 120 GHz for superconductive circuits, and do provide the needed rework capability. However, even with automated dipping machines, the poorly controlled fluid dynamics of and chemical and temperature non-uniformity within the essential bath of molten solder makes this approach an art-form rather than a manufacturing technology. The Si industry standard of gold balls or studs has the required manufacturability, but lacks the ability to place small enough balls closely enough together to handle such aggressive clock pulse rates. It also has problems with reworking. The incremental cost of this capability for volumes of <1000 units per week should not exceed $300K for a facility already engaged in flip-chipping more standard chips.

PHASE I: In phase 1, the vendors should elaborate the details of a design concept presented in the proposal for a bonding process that meets these requirements.

PHASE II: In phase 2, the vendor should construct a prototype unit capable of performing this task and demonstrate its success and uniformity using chips provided as GFE.

PHASE III: Sell beta test and fully productized units to research laboratories manufacturing custom circuits, especially RF system components, to the government and high tech industry.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
Silicon technology's movement toward multiple processors CPU is an example of a multichip module. Being able to bond multiple chips made from different device technologies together will allow functionality to be optimized without the expense of developing cofabrication capabilities. It should find application in many the same places as 3D packaging and grow in importance as nanotechnology matures (which will need small contacts).

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2. Bauer, C.E.; Wu Fei Jain; Taran, A.; 4th Electronics Packaging Technology Conference, 10-12 Dec 2002. Page(s):276 - 279 http://ieeexplore.ieee.org/xpl/RecentCon.jsp?punumber=8446

3. John H. Lau, Editor, "Flip Chip Technologies," McGraw-Hill, NY, 1995. ISBN 0-07-036609-8

KEYWORDS: multi-chip modules, flip-chip bonding, rework, solder bumps, gold studs, high speed circuits

N07-T019 TITLE: Distributed, Robust Unmanned Air Vehicle Management in Support of Small Expeditionary Units

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Human Systems

ACQUISITION PROGRAM: Large Tactical Sensor Network Enabling Capability, FORCENet FNC

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop multi-disciplinary distributed control algorithms and human interface concepts to allow control of multiple unmanned naval air vehicles to be shared among multiple non-collocated warfighters in small expeditionary units. This should focus on high-level allocation and tasking of assets based on small unit intelligence needs in a way that is robust to a limited communications environment with limited resources. This effort is not focused on the development on lower level autonomous vehicle technologies such as vision, sensor processing/fusion, and guidance, navigation, and control, air platforms, sensors, communications technologies, completely centralized control of multiple vehicles, approaches that are not suitable for small unit needs, or hardware of any type.

DESCRIPTION: Expeditionary forces must monitor a large and complex area continuously in order to identify potential threats and take action to prevent them. Due to the dynamic nature of the battlefield, small units will need to be able to rapidly re-allocate and re-task unmanned air vehicles to support time-critical intelligence needs. This must be done through relatively simple and user-friendly human interfaces that are as non-intrusive to the user as possible. Due to the challenges of this environment, it may be necessary to use multiple sensor modalities to detect particular types of activities. It is envisioned that in the future there will be large tactical sensor networks that support network-centric management of unmanned vehicles and sensors. However, there will likely be significant communications limitations and it will be a challenge to ensure that the warfighter can rapidly and reliably request services that ensure the right data is collected by the right sensor in support of any specific intelligence requirements. Depending on the type of environment and intelligence requirement, the approach may need to take into account a wide variety of factors such as terrain, weather, the vehicles dynamic maneuvering capabilities, multispectral signature information, threats/obstacles, and communications limitations. While it should be a simple as possible for the user to input an intelligence need, the desired optimization criteria associated with a particular intelligence requirement may be complex and multi-objective and include factors such as the quality or type of data required, the likelihood of detecting or identifying a particular type of target, the exposure of the UAV to threats, time on station or revisit rates, deconfliction with other vehicles, and “time-on-target” specifications that require a particular goal to be achieved by a particular time or to be maintained through a particular time. The vehicle may also be under a wide range of constraints, such as rules of engagement or the need to remain within specific airspace constraints. Also of relevance in some missions may be either avoiding detection by hostile forces or at least confusing hostile forces as to the intent of the unmanned vehicle’s data collection actions.

This topic will examine distributed planning and control algorithms and user interface concepts to enable multiple users to input small unit intelligence needs, and then have these decomposed into specific mission tasks and allocated among UAV’s in a robust, distributed way despite limited communications. This should support rapid changes in collection requirements and force disposition and contingencies and also provide the user with some understanding of the likelihood of meeting his intelligence requirement within the specified constraints. Some significant technical challenges for this type of approach in a limited communications environment include identifying what information needs to be communicated between each system for reliable allocation and planning, determining how user intelligence needs/intent can can best be defined and how to decompose and allocate tasks based on this, determining how access to limited sensor resources should be dealt with when users have competing or conflicting requirements, ensuring planning is robust to uncertainty, ensuring system capability degrades gracefully if communications are limited, and ensuring the user has adequate understanding of the capability of the system.

PHASE I: Develop an initial version of the proposed approach for a limited set of mission tasks and platform types with sufficient functionality to demonstrate feasibility and allow some limited experimentation. The distributed control algorithm experiments should be with limited-fidelity simulation elements to show closed loop performance and robustness. Simulation may include some limited-complexity vehicle models, sensor models, communications models, target models, and threat models, depending on what would be most suitable to examine the particular approach. Human interface concepts for that particular control approach may be examined with a simple mock-up or with some limited functionality to get feedback from.naval operators and domain experts. Develop metrics to evaluate the system in Phase II and determine how the approach could interface with Marine Corps intelligence systems.

PHASE II: Further develop the proposed approach for a broader set of intelligence needs and system types in a more complex dynamic and unstructured environment and integrate them with a medium-fidelity simulation and sufficient autonomy components to perform laboratory operator in-the-loop experiments and comparison with benchmarks. If feasible, experiments may also be conducted with the use of inexpensive UAV’s. Experiments should include a focus on determining the sensitivity of the system to a variety of factors such as communication degradation and uncertainty in the environment. Revise evaluation metrics as necessary.

PHASE III: Integrate the software with other naval tactical sensor network software and/or unmanned systems and participate in integrated demonstrations of multi-vehicle operations.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
Improved control and human interface algorithms will useful for a range of commercial unmanned system and other automation applications including search and rescue and other first responder uses.

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3. M. B. Dias and A. Stentz, "A Comparative Study Between Centralized, Market-Based, and Behavioral Multirobot Coordination Approaches," Proceedings of the 2003 IEEE/RSJ International Conference on Intelligent Robotics and Systems (IROS), October 2003.

4. C. Hawthorne, E. VanGiesen, D. Scheidt, B. Chalmers, C. Chiu, “Autonomous UAV Swarms for Detection and Classification of Chemical and Biological Agents,” AUVSI Unmanned Systems North America, 2006.

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8. P. Chandler, “Cooperative Control of a Team of UAVs for Tactical Missions,” Proceedings of the AIAA 1st Intelligent Systems Technical Conference, 2004

KEYWORDS: Unmanned Air Vehicle, UAV, distributed control, human system interface, human robotic interface

N07-T020 TITLE: Virtual Dismounted Infantry Toolkit

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: MARCORSYSCOM PM Marine Expeditionary Rifle Squad (PM MERS)

OBJECTIVE: Develop an advanced integrated physics based virtual model of the Dismounted Infantryman that assists in the study of the ergonomic and physical interactions of the Dismounted Infantryman, his equipment, and his environment. In addition to assisting in equipment design, it will allow trade-offs to be made between survivability, weight, and combat load for various mission profiles.

DESCRIPTION: The Infantryman’s role is unique in the DoD’s arsenal. Unlike mechanical platforms, like ships, land vehicles, and aircraft that are designed to be technologically self-contained and are often limited only by the extent to which their component materials can be engineered, the Infantryman is inherently limited by nature. Strict Ergonomic and Physiologic rules dictate how much ‘power’ an Infantryman can produce in order to physically propel himself, cognitively prepare himself, and holistically sustain himself under the rigors of extended combat. The most typical approach for enhancing and supplementing Nature's limitations is to develop technical solutions to each identified weakness. This process, jokingly referred to as the "Christmas Tree" approach to design with each item being developed independently of the others, has led to the current state of affairs where, in many cases, the combined mass of the typical Infantryman's Combat Load exceeds 50% of the wearer's weight. Since various teams design each of these technical solutions independent of each other and without regard to their effect on the Infantryman as a system, the combined elements are often not interoperable or optimized for efficiency. There is much redundancy, wasted space, and added weight for little return on investment.

The applied sciences of human factors and ergonomics offer powerful tools for optimizing physical and cognitive performance and the interactive effects among brain, body, and combat gear. These tools have yet to be fully harnessed to the challenge of optimizing the Infantryman. To do so would require broad and robust modeling capabilities that support rapid prototyping and testing of individual and integrated Infantryman equipment in a) realistically simulated military applications, b) across a wide range of parameters. Modeling and simulation effort would need to account for external environmental models that capture relevant factors like terrain, weather, and topography, that provide active representations of body movement in combat, and that couple these representations dynamically.

This STTR would develop an easy to use Virtual Dismounted Infantryman Toolkit that will allow designers and users to interactively assess the system tradeoffs of various real and proposed infantry individual equipment, with particular emphasis on how each component interacts with other ones, under a range of simulated combat conditions. The system will include a 3D representation of the physical characteristics of the Infantryman including fully articulated joints as well as some of the more critical physiologic/cognitive ones, like fatigue. It will also allow developers to define the combat environment within which the overall suite of components may be evaluated. The Virtual Infantryman will allow various components to be modeled and subsequently placed on different locations of the Infantryman and it will accurately reflect the changes to stability and its impact on motion and gait when executed within the simulated combat environment. Importantly, this system will not only allow developers to specify and test their prototype system; it will also allow them to model the entire suite of existing elements worn by Infantryman, in order to assist in real-time trade-off analyses. Additionally, it will provide a real-time, modifiable, testing environment in which the entire suite may be assessed across a range of combat conditions.

This effort should leverage and expand upon the Army Technology Objective (ATO) "Soldier Protection Strategies". The Dismounted Infantry performance tasks in the ATO currently modeled are a small set and include weapon aiming, foot marching (w/ load carriage), running, stairs, and grenade throw. A more comprehensive set of dismounted infantry tasks is needed, particularly those involving urban operations and distributed operations. In addition, the model should have fully scalable anthropometry to cover full range of body shapes/sizes. The fatigue model should include both aerobic and anaerobic components. The model should also represent the effects of environmental conditions (e.g. heat stress) and comfort.

Body armor is an increasingly important and integral piece of equipment and we need to be able to model advanced and emerging concepts such as flexible and scaled body armors. Body armor representations either designed within the virtual toolkit or imported from existing designs must be compatible with the Individual Casualty Estimation Methodology (ICEM), a model that predicts casualty reduction with various armor concepts.

PHASE I: Phase I will develop a concept for simulating a Virtual Dismounted Infantryman so that the interaction between the Infantry, his individual equipment, and the environment can be studied. This effort should leverage and expand upon the work begun under the ATO "Soldier Protection Strategies".

PHASE II: Phase II will develop the Virtual Dismounted Infantry Toolkit to include the features described above. In addition, there will be research to validate the results of the model with Infantry equipment.

PHASE III: Phase III will result in fully functional, validated tools for the Virtual Dismounted Infantry. In addition to design tools, there will also be easy to use PC based tools that will allow Dismounted Infantry leaders to make informed decisions about what equipment to bring for a particular mission.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:

This technology will be directly applicable to law enforcement, sports equipment manufacturers, and vehicle manufacturers. Current virtual human models require significant skill to use. This STTR, if successful, will deliver easy to use, but highly powerful models which can be used for equipment design, maintenance, and manufacture.

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KEYWORDS: Modeling, Simulation, Human Performance, Human Factors, Ergonomics

N07-T021 TITLE: Composite-to-Metal Jointing Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ships, PMS 500, DDG 1000, LCS, CGX

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative joining methodology and joint repair methodology for Composites-to-Metals that are not prone to sudden failure, have much higher strain-to failure, and increased energy absorption than conventional bonds.

DESCRIPTION: Novel methods for bonding to metals, which promise to overcome the weakness of the bonds, and sudden failure under combined in-plane and out-of-plane dynamic and cyclic loads have large application in military systems. The science of bonding and joining dissimilar materials has resulted in good understanding of failure mechanisms and the possibility of developing of joining methods with high structural reliability. The STTR will address the development and proof of concept for innovative joining methodology for Composites-to-Metals that are not prone to sudden failure,have much higher strain-to failure, and increased energy absorption than conventional bonds. Included in this effort is the development of the methodology to repair these joints during the long and severe service life of military systems.

PHASE I: Develop candidate joining methodologies for large composite-to-steel joints for ship applications, including materials, method of joining to achieve durability, cyclic loading and resistance to sea environment. Develop candidate joint repair methodologies that are compatible with the proposed joining methodology (repair methodology may be depot, intermediate maintenance activity, or organizational level).

PHASE II: Perform testing of the selected candidate(s) under dynamic and cyclic loadings, to illustrate that the joint does not fail prematurely, or suddenly, and is as strong as the parent material. Conduct a demonstration of the selected repair methods on representative scale specimens, and conduct dynamic and cyclic loading to illustrate joint repair properties.

PHASE III: Optimize joints for large structural component, investigate durability and provide means for scale-up, or develop a health monitoring system for joint reliability. Conduct a full scale (large 10' panel) repair and dynamic and cyclic loading test demonstration.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: In addition to Navy ships applications, the proposed composite-to-metal joining methodology has a very wide spectrum of applications in military aircraft, commercial aircraft, and automotive and construction industries.

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KEYWORDS: joining; Composite; metals; adhesive; joint strength; joint repair; durability

N07-T022 TITLE: Neutrally Buoyant Pressure Tolerant Rechargeable Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PMS 403 MRUUV (Mission Reconfigurable Unmanned Undersea Vehicle) Program

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate pressure tolerant secondary battery cells that have very high gravimetric energy density (>400 Wh/kg), specific gravity less than 1, and are producible in large (>20 Ah) cells. These batteries will enable new UUVs and ROVs to have a significant increase their current range or decrease the current size.

DESCRIPTION: Future unmanned undersea vehicle (UUV) missions will require greater energy that is available within current size and weight constraints. Existing pressure tolerant batteries eliminate the volume and weight of a pressure housing, but they have high specific gravities requiring large volumes of foam to be neutrally buoyant. The foam increases the size, weight, and cost of the current vehicles and the difficulty of maintenance. Recent research on the rechargeable lithium sulfur battery chemistry has demonstrated a gravimetric energy density over 400 Wh/kg and a chemical potential of 2450 Wh/kg, nearly 5 times that of lithium ion cells. Other rechargeable chemistries may also afford improved energy densities in pressure-tolerant, neutrally buoyant designs. An optimum battery chemistry for UUVs would have a specific gravity less than or equal to sea water with as high a gravimetric energy density as possible. The focus of this topic is the development and test of packaged cell-level technology that will ultimately be part of a complete battery system.

Desired chemistries and current collector designs would minimize the specific gravity, optimizing the battery for UUVs.

To increase transition potential to current UUV acquisition programs, the cost of the new cells should be ~$4/Wh; equivalent to current high-energy capacity lithium ion cells.

PHASE I: Develop and demonstrate innovative pressure tolerant battery cells with very high gravimetric energy density, a specific gravity less than 1, and that are producible in large (>20 Ah) cells. Key acceptability factors including energy density, specific gravity, and cost will be addressed in the final report. Small cell sizes that are suitable for development and proof of the chemistry should be demonstrated.

PHASE II: Build and demonstrate one lot of prototype cells suitable for advanced laboratory and supervised field-testing. Develop and implement a test plan that will evaluate the cells through UUV missions and life cycles.

PHASE III: Prepare a manufacturing plan and marketing plan to sell this product to the government as well as the private sector. Make the necessary teaming arrangements with the manufacturers of the components used in this product. Develop battery cells for integration into a Mission Reconfigurable Unmanned Undersea Vehicle System (MRUUVS).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Technology developed in this program could find commercial application in oil industry and research UUVs.

REFERENCES:
1. Navy UUV Master Plan. April 20, 2000 http://www.auvsi.org/resources/UUVMPPubRelease.pdf

2. The Navy UUV Master Plan. November 9, 2004. http://www.chinfo.navy.mil/navpalib/technology/uuvmp.pdf

KEYWORDS: unmanned undersea vehicles; rechargeable battery; neutrally buoyant; pressure tolerant

N07-T023 TITLE: Dynamical Modeling of Discourse for Team Performance Analysis and Enhancement

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: No acquisition program specified.

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Apply computational modeling technology with a focus on dynamical systems modeling to automatically record and analyze flow characteristics of team discourse. Derived metrics will be used to interactively assess and measure team shared understanding and to provide tools and guidelines for improving team training and performance.

DESCRIPTION: Defense Transformation and Network-Centric Operations has created the requirement for highly responsive, networked teams. The increased focus on Coalition Operations has also driven the need for agile, multicultural teams to respond quickly to asymmetric threats. The ability to interactively assess team synchronization and shared understanding could provide real time information to adjust team knowledge, team member assignment and institute corrective action/training. New discourse flow analysis techniques, which can operate unobtrusively and on a real-time basis, can provide a means for intervention in team activities. Discourse analysis and its application to understanding and predicting team performance has been demonstrated in a lab environment and has been applied successfully to experimental UAV command and control teams. This solicitation proposes the extension of this technology by adding a temporal factor to discourse analysis in the form of dynamical modeling. This could provide a time-phased assessment of how team performance varies over the entire task period rather than just a snapshot in time. This capability would provide an understanding of how teams build knowledge, share information and develop team consensus.

PHASE I: Assess the state of the technology in flow analysis of discourse and select a method that is amenable to dynamical modeling. Determine the role that semantic content may play in the model and how this factor could be addressed in view of the operational capabilities required. Develop a system concept, design and associated architecture. Propose a prototype for application in quick-reaction small team situations.

PHASE II: Develop and demonstrate a prototype system in a lab or simulation environment. Conduct one or more lab or controlled experiments to validate the tool and quantifiably demonstrate its benefit in improved team decision-making performance. Conduct testing to prove feasibility in an operational experiment or training scenario. Prepare guidelines and documentation for tool transition to an operational setting. Validate, standardize and document underlying software for application purposes and implement in a field experiment.

PHASE III: Coordinate with user subject matter experts to instantiate a working model with actual data, get user commitment for training and maintenance of the application. Field test tool in an operational setting and produce improved performance measures. Implement the tool in a comprehensive package that would include an intuitive graphical user interlace (GUI)

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology product could be applied to any collaborative or team problem solving situation where it is necessary to develop a team consensus on an issue or product. Product development teams and business processes teams would be a specific target.

REFERENCES:

1. Cooke NJ, Gorman JC, Kiekel PA, Foltz P, Martin M. Using Team Communication to Understand Team Cognition in Distributed vs. Co-Located Mission Environments. Technical Report for ONR Grant no. N00014-03-1-0580, 2005.

2. Abarbanel, H. D. I. (1996). Analysis of observed chaotic data. New York: Springer-Verlag.

KEYWORDS: Discourse Analysis, Team performance; Dynamical Modeling

N07-T024 TITLE: <u>Distributed Co-operative Automatic Target Recognition (ATR) Using Multiple Low Resolution Sensors</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PMA 201

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The main objective of this STTR topic is to develop embedded or on-board techniques and algorithms that allow multiple lower resolution sensors on smaller unmanned systems to cooperatively perform high accuracy ATR. The focus is on the advanced on-board algorithm technologies and not on the sensors per se.

DESCRIPTION: Many of today’s ATR applications are designed for weapon systems that have high resolution electro-optical sensors and are processed utilizing high-end computing capability. Predominantly these applications are on manned systems or large unmanned systems (such as the SHARP on the F/A-18 E/F) due to the power and weight required for high resolution processing capabilities. However, most of unmanned vehicles (UxVs) are smaller in size, less expensive, and, thus, can afford to have only sensors that have low resolution and a limited onboard processing capability. If a single one of those types of systems were used to perform ATR, the result would be a determination with a large percentage of uncertainty that is too late to be actionable. Off-board processing of the sensor feeds has been used, but at the cost of increased latency and significant bandwidth requirements; however, this may still not reduce the uncertainty if the sensors do not co-operatively share the low resolution images with different looks to improve the ATR accuracy. To reduce the demands on available bandwidth, to co-operatively share the information from low resolution images of different looks and to use this information to perform high accuracy ATR, innovative distributed co-operative ATR techniques must be developed. The techniques must address the distributed and co-operative nature of the problem and offer a solution that optimizes resources (i.e., communication bandwidth, on-board processing capabilities, sensors) and sensor placement to provide high accuracy ATR (i.e., pd close to 98% and pfa less than 5%).

PHASE I: The Phase I research will identify and evaluate techniques and algorithms necessary to demonstrate distributed collaborative high accuracy ATR capabilities. Phase I will focus on defining the concept and developing small-footprint, embeddable algorithms in order to prove technical feasibility.

PHASE II: In Phase II, the performer will develop and integrate the distributed collaborative high accuracy ATR concept and algorithms into a hardware-in-the-loop prototype system. The Phase II effort will focus on demonstrating a robust collaborative distributed ATR technique/algorithm using multiple low resolution sensors. The goal will be for the integrated technologies to be demonstrated in field with actual or surrogate small UAVs/UGVs.

PHASE III: The successful Phase II could lead to transition of this technology to PMA 201 where they are using UAVs/UGVs to detect and recognize ground moving or maritime targets. Currently they do not have distributed collaborative ATR algorithms that are very much needed to achieve the goal of high accuracy ATR. The technology developed under this STTR will provide that much needed capability. The performers of this STTR should work with PMA 201 IPT lead at NUWC, Pauxent River, MD during phase II to understand the hardware (i.e., sensor and computing resources) details and to make sure that the algorithms developed will transition to this hardware without much effort.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
In many commercial applications such as law enforcement, disaster response, automated manufacturing and constructions systems, low cost low resolution distributed sensors are used for object detection and recognition. However, they lack the distributed algorithms to perform high accuracy ATR. Hence, the technology developed under this STTR would have significant impact on these commercial applications.

REFERENCES:
1. Edwards, Sean J., Swarming and the Future of Warfare, RAND, RGSD-189, 2005.

2. Beard, Randal W. et al, Target Acquisition, Localization, and Surveillance Using a Fixed-Wing Mini-UAV and Gimbaled Camera, IEEE International Conference on Robotics and Automation, 2005.

3. Prithviraj Dasgupta, "Distributed Automatic Target Recognition Using Multiagent UAV Swarms," AAMAS'06 May 8–12 2006, Hakodate, Hokkaido, Japan.

KEYWORDS: unattended sensors; embedded algorithms; distributed co-operative ATR; sensor correlation; low resolution low cost sensors; small unmanned vehicles

N07-T025 TITLE: Autonomous UAV Collision Avoidance

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

ACQUISITION PROGRAM: US Marine Corps PMA-263

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop a radar sensor compatible with small UAVs that permits safe/reliable autonomous flight in civilian airspace.

DESCRIPTION: The goal of this topic is to develop a radar based collision avoidance sensor suite (RCASS) compatible with small UAVs (< 11 foot wingspan, i.e. Silver Fox class size) for collision avoidance supporting autonomous flights in air spaces co-located with manned air space. Current UAV flights are severely restricted to avoid potential collision with other air platforms. Federal Aviation Administration (FAA) Regulation 7610.4 [1] states that remotely operated aircraft must have an equivalent level of safety, comparable to see-and-avoid requirements for manned aircraft, to satisfy FAA safety requirements. UAVs operating like manned aircraft in the National Air Space have additional FAA requirements. The RCASS must be effective against all air traffic, with or without transponder-based collision avoidance systems such as TCAS [2] or ADS-B [3].

One component of the RCASS may include omni-directional Radar [4]. The RCASS system design must provide an energy density per unit solid angle supporting detection at ranges compatible with collision avoidance. Further, the design must satisfy typical small UAV payload constraints. For system design purposes assume <10% of payload volume, weight, with 200 cc, 1.1 Kg, and <40 W as an upper bound.

The RCASS must also be electromagnetically compatible with traditional UAV sensors including EO/IR, magnetic detectors, as well as on-board avionics (including GPS) and wireless communication systems.

For autonomous UAV flight in heavy air traffic environments, the UAV must sense or be aware of the coarse 3-D trajectories of neighboring air traffic relative to its own flight trajectory. The RCASS processor will update and maintain its own internal map of the neighborhood air picture, as well as optimizing its actual 3-D trajectory path with its pre-planned 3-D trajectory as a constraint. The RCASS is a point solution and does not require modifications to the external air traffic control system in CONUS or worldwide.

ONR is interested in any intelligent autonomous systems that would be able to perform the sense and avoid function while adhering to the size, weight and power constraints of small UAVs. The Navy will only fund proposals that are innovative and involve technical risk.

PHASE I: Provide an initial system design that demonstrates scientific merit and capabilities of the proposed Radar based RCASS system for small UAVs. This includes a calculation of the RCASS awareness volume surrounding the UAV. The volume is to be determined in part by the limited detection ranges of the sensors. It must support the slower response time of UAVs relative to nearby higher speed military and civilian aircraft kinematics. The Phase I study also includes a high level design of the Radar sensors to support the RCASS awareness volume, as well as a high level design of the RCASS hardware (supporting the < 10% of the volume, weight, and power allocated to the UAV's normal payload). A software simulation of the collision avoidance function in a heavy civilian traffic environment with the limitations of the proposed RCASS system design will demonstrate the efficacy of the approach.

PHASE II: Design, build, and test an affordable RCASS for a small UAV. Demonstrate collision avoidance. In this phase, a live field test with a surrogate manned aircraft must be documented. Obtain FAA guidance for PHASE III transition.

PHASE III: Obtain FAA certification for autonomous flight in CONUS with UAVs equipped with RCASS. Also demonstrate a manufacturing process that supports volume cost savings to enhance the affordability for dual usages.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Autonomous UAV operation lowers man power costs and is key to ubiquitous deployment by the commercial sector. Commercial applications include surveillance of private oil and gas pipelines, the national electronic grid, crop assessment (farming), forest fire fighting, automotive traffic surveillance, and sky based communication networks.

REFERENCES:
1. FAA, FAA Order 7610.4, available from www.faa.gov, 2006.

2. FAA, "Introduction to TCAS Version 7," US Department of Transportation, Federal Aviation Administration, 2000.

3. RTCA, "Minimum Aviation System Performance Standards For Automatic Dependent Surveillance Broadcast (ADS-B)", RTCA/DO-242A, Washington DC, 2002

4. Skolnik, M., "Improvements for Air-Surveillance Radar,"IEEE Radar Conference, pp 18-21, Waltham, MA, 1999.

KEYWORDS: Autonomous Flight; Collision Avoidance; TCAS; ADS-B, Omni-directional Radar; UAV; See and Avoid; FAA; Naval Aircraft.

N07-T026 TITLE: High-Power Compact Power Electronics for Electric Torpedoes

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-SUB PMS 404, Electric Torpedo Program

OBJECTIVE: Develop and demonstrate high-power compact power electronic converter with controllers for electric torpedo and underwater vehicle propulsion systems. Candidate power electronic converter designs require high power density to meet volume and weight requirements.

DESCRIPTION: Electric propulsion torpedoes offer several benefits over conventional thermal engine powered torpedoes. The benefits are: lower fleet exercise costs, faster turn-around time, lower noise, no gaseous wakes and depth independence. A propulsion motor drive using the state-of-art power electronic converter is a key enabling technology for the envisioned torpedo electric power and propulsion systems. The motor drive requirements of a torpedo electric drive system will differ in critical ways from power conversion components developed for Navy manned and unmanned underwater vehicle propulsion. A need exists to develop candidate compact power electronic converter technology suitable for use as a torpedo propulsion motor drive.

The required developmental efforts include: 1) detailed modeling and simulation of power electronic converter design, including influence of advanced control algorithm and representations of DC supply and motor circuit parameters; 2) assessment of power system dynamics and output power quality; and 3) consideration of thermal design of proposed unit packaged for torpedo insertion. The compact power electronic converter will take DC power input and provide variable frequency AC power output for propulsion and other vehicle loads. Near sinusoidal current output is desirable. The power converter design and control algorithm should take advantage of current advancement in power electronics and control, such as the SiC switching device currently under development by DARPA and the others.

PHASE I: Feasibility Study and Preliminary Design--Determine the dominant factors that affect motor drive power converter design decisions and develop a first order motor drive compact power electronic converter. Implement first order design tools, and modeling and simulation to recommend top level power electronic converter topology and advanced control approach.

PHASE II: Detailed Design, Prototype Fabrication and Testing-- Design and fabricate prototype suitable for test and evaluation. Conduct laboratory testing to evaluate the operation of power converter. The converter will be interconnected with DC power supply and loaded motor representative of a torpedo electric drive system. Measurements will include drive input and output voltage and current, airborne and structureborne acoustics, and motor shaft torque.

PHASE III: Demonstration and Transition—Demonstrate the integrated power electronics with motor and propulsor in water. Based on the results from Phase II, transition the power electronics to Navy Laboratories and/or torpedo manufacturers for electric torpedoes.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
The compact high-power electronics can be applied to many air and ground vehicles, as well as control systems in power plants and rotating machinery systems. The conversion from DC power to AC power and then to mechanical such as powering the propeller and rotating machinery requires robust and compact converters and controllers.

REFERENCES:
1. Wang, J. and Williams B. W., “Evaluation of High-Voltage 4H-SiC Switching Devices,” IEEE Transaction on Electron Devices, vol 46, no. 3, March 1999.

2. “Technology Needs for Torpedo Development,” Letter to the Chief of Naval Research from the Undersea Weapons Program Office, dated 26 May 2006.

KEYWORDS: power electronics; electric propulsion; power converter; controllers; AC-DC converter; switching devices

N07-T027 TITLE: <u>Advanced Catalyst Structures to Enhance Fischer Tropsch Process, Selectivity, and Product Yield</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Defense Logistics Agency Alternative Fuels infrastructure

OBJECTIVE: This topic explores potential high reward technologies that can create compact, ruggedized Fischer-Tropsch Synthesis (FTS) catalyst structures with the capability of operating in extreme environments This catalyst will be designed to optimize selectivity to C9 to C16 (JP5 range) hydrocarbon yield, through enhanced mass contact and high thermal-transfer characteristics, with the ability to run in various orientations and configurations.

DESCRIPTION: With increasing power needs for all aspects of military operation, coupled with the major security issues associated with dependence on foreign sources of raw materials such as crude, there is an increasing desire to be able to utilize technologies that can produce military-acceptable synthetic fuels for use in various applications using varying locally available feed stocks. The war fighting capabilities of the Navy and the military can be greatly enhanced by the availability and accessibility of synthetic fuels. Presently, although there are many nationally available feed stocks that are excellent for the production of synthetic fuel, The current conversion method of these feed stocks combined with the transportation costs associated with bringing the feed stocks to the processing facilities makes the timely conversion into synthetic fuels cost prohibitive. Therefore, there is a immediate need for fuel manufacturing and fuel processing equipment that are small, modular, easily packaged, able to adapt to varying, feed stocks and locations. This equipment could be co-located with locally available feed stocks to enhance availability and affordability. Greater synthetic fuel availability would shift the supply paradigm from one of dependence on foreign supply to one of predictable availability; local flexibility, and U.S. energy independence

Fuel processing and fuel manufacturing plants such as those employing Fischer-Tropsch Synthesis (FTS) extensively utilize heterogeneous catalysts as a cornerstone for performing fuels synthesis and further integrated chemical processing operations. Current FTS systems produce extremely wide hydrocarbon product distributions., which require extensive recycle and separation processes to yield product cuts suitable for military applications. It is important to the realization of an inherently space and material-efficient, modular FTS system for military use, that new catalyst structures and methodologies are created that: are scalable/modular; have adjustable and tunable product selectivities and residence time distributions; provide high volumetric reactivities; are easily reduced in size and readily amenable to process intensification; are robust and operable in a variety of orientations, configurations and environments; and possess structurally inherent means to balance surface kinetic rates against concomitant transport rates of heat and mass. These parameters are critical, as they will inherently determine the yield, and distribution of the hydrocarbon species from the reactor, the likes of which need to be quite narrow and inline with the parameters set forth in the military performance specifications of JP-5. Through proper design of an FTS catalyst and its associated bulk structure, with full consideration of the parameters that influence the kinetic behavior of the various reactions, designs may be created that allow narrow product distribution with high feedstock utilization and minimal recycle requirements.

As a result, there is a fundamental need for applied innovative research into catalytic materials as well as structural architectures that enable FTS to be realized in a modular, flexible and inexpensive manner, to produce military fuels. Due to the exothermicity/endothermicity involved in processing high energy density fuels, fully packaged catalyst structures are required which possess high inherent heat transfer rates thereby offering the opportunity to better control intra-bed hot spots and product selectivity. High selectivity to product specifications is necessary to promote not only fuel quality but also reduce the balance of plant (BOP) requirements for post processing operations. High inherent heat transfer rates also permit fundamental changes and simplifications in the form factor and geometry of potential reactor(s), with respect to the number of individual reactor tubes/units with a corresponding reduction in process controls, system actuators and overall system complexity. Additionally, such benefits will allow the realization of a system that can be integrated so that it has the ability to be transported in module fashion by ship or by air, and operate with quick startup properties, for the purpose of replenishing the needs of a military operation as quickly as possible. The goal of this STTR effort is to create a compact, ruggedized Fischer-Tropsch Synthesis (FTS) catalyst structure designed to optimize selectivity to C9 to C16 (JP5 range) hydrocarbon yield, through enhanced mass contact and high thermal-transfer characteristics, with the ability to run in various orientations and configurations.

PHASE I: Analysis will be performed to determine promising catalyst materials which exhibit extremely high activity and selectivity towards production of narrow hydrocarbon distributions. Additionally, structural analysis will be performed to determine the benefits with respect to kinetic mass contact and thermal transfer enhancement. Based on catalyst and structural analysis, a notional laboratory-scale design will be created for a FTS reaction test bed that yields a hydrocarbon distribution as discussed above.

PHASE II: Additional design and analysis will be performed to produce a laboratory scale demonstrator that produces 1-2 liter(s) of fuel per day. This demonstrator will be analyzed to determine the operating parameters of an FTS reactor capable of producing fuel at a rate equivalent to the utilization of a 30% efficient 5KW generator.

PHASE III: Based upon the notional design produced in the phase II, a 5KW equivalent production unit will be built that is capable of operating on syngas derived from reformed natural gas.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Advanced methods of producing liquid fuels from a variety of feedstocks that are derived in accordance with locally available materials (e.g. biomass, coal, natural gas, sewage, etc) would be directly useable for small to medium scale production facilities for liquid transportation fuel, independent of foreign crude sources, particularly at inland locations. This model has been realized in the arena of biodiesel production, in regions that have large quantities of vegetable-oil, animal fats, etc. FTS could potentially be used synergistically with other process technologies or electrical production for further efficiency enhancements.

REFERENCES:
1. Sie, ST, process development and scale up: IV Case history of the development of a Fischer-Tropsch synthesis process, Rev. Chem. Eng. 1998, 14, 109-157.

2. Jager, B.; Dry, M.E.; Shingles, T.; Steynberg, A.P., Experience with a new type of reactor for Fischer-Tropsch synthesis, Catal. Lett. 1990, 7,293-302.

3. Behrmann, W.C.; Mauldin, C.H.; Pedrick, L.E., Patent WO 9414735 1994, Exxon.

4. Koros, R.B., U.S. patent 5384336 1995, Exxon

KEYWORDS: Fischer-Tropsch; Synthesis; fuel; catalyst; modular; structure

N07-T028 TITLE: Physiological-based tools for virtual environment fidelity design guidance

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: MARCORPSYSCOM PM Training Systems (PMTRASYS)

OBJECTIVE: To investigate and develop training assessment and guidance tools that utilize operator behavior and physiology to determine virtual environment (VE) effectiveness and transfer of training.

DESCRIPTION: Simulations are being used more and more for training purposes. Advances in virtual technologies are enhancing the ability to create realistic virtual environments (VEs) in which the military can train skills that are too costly, dangerous or otherwise impossible to practice. Many have assumed that the more realistic the VE, the better the transfer of training to real world tasks. However, some aspects of fidelity are likely more important than others. This has been traditionally determined by performance via a user-centered design model that involves multiple design iterations. Each time design modifications are made, end users are tested on the VE and their performance is compared to performance on the prior VE design. Improved performance is assumed to be related to improved design. This method of design focuses on trial and error; it is time consuming, undirected, and may result in false associations between performance and VE parameters. For example, unless each aspect of the new simulator design is introduced separately, it will not be known which design improvements impacted performance. Additionally, in some cases, performance in the simulator may be improved by simplifying the simulation interface or aspects of the task; this increased performance in the simulation environment will not likely transfer to the real-world task environment.

Tools are needed to provide a more comprehensive assessment of the quality of interaction with a simulation. Knowledge about changes in recordable brain and peripheral bioelectrical signals may lead to the development of more effective VEs, for example, tuning the intensity, the frequency, and the timing of a given combination of stimuli to the desired level for a given category of users or purpose during the development and the application of a VR product [3]. Meehan et al. used physiological measures to assess VE effectiveness in terms of individual aspects of VEs (multiple exposures, passive haptics, frame rate, and latency) on presence [2]. Additionally, Mager et al. demonstrated that it is technically possible to get sufficient electrophysiological responses in a stereoscopic VE [1]. A system capable of dynamically detecting changes in operator behavior and physiology throughout a VE experience and comparing those changes to operator behavior and physiology in real-world tasks, would allow researchers to determine which aspects of VE fidelity will have the highest impact on transfer of training.

PHASE I: Provide a study that (1) investigates technologies to monitor the trainee and develop metrics in order to gauge simulation fidelity: (2) identify possible algorithms for automating the detection of simulation fidelity; (3) proposes a framework consisting of a combination of hardware and software that could be integrated and or deployed along side a virtual reality training environment.

PHASE II: Implement the proposed framework and demonstrate its effectiveness in gauging simulation fidelity as it pertains to transfer of training. Ideally, this testing would be done using operationally-relevant training materials.

PHASE III: Refine and integrate the validated framework and its associated systems into Marine training facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
Successful development of the proposed training assessment technologies should have application within commercial and industrial training facilities where a decreased time to transition untrained employee to trained employee has significant cost savings, as well as training positions in which performance errors could result in injury to a human, such as the medical field (i.e. surgical simulation training) as well as jobs involving operation of dangerous or expensive equipment. Similarly, provided the developed system is affordable and easy-to-use, students at all levels would benefit from an accelerated learning system. Finally, individuals with attention disorders, such as Attention-Deficit-Disorder (ADD), may also benefit from such a system, as the system would focus on the individual's neuro-physiological response to training, rather than simply performance metrics.

REFERENCES:
1. Mager, Bullinger, Roessler, Mueller-Sphan, and Stoermer, Monitoring Brain Activity During Use of Stereoscopic Virtual Environments. CyberPsychology & Behavior, 2000. 3(3): p407-413.

2. Meehan, Razzaque, Insko, Whitton, and Brooks, Review of Four Studies on the Use of Physiological Reaction as a Measure of Presence in Stressful Virtual Environments, Applied Psychophysiology and Biofeedback, Vol. 30, No. 3, September 2005: p239-258.

3. Pugnetti, Meehan, and Mendozzi, Psychophysiological Correlates of Virtual Reality: A Review. Presence: Teleoperators & Virtual Environments, 2001. 10(4): p384-400.
KEYWORDS: virtual reality; simulation; transfer of training; physiology; behavior; training effectiveness

N07-T029 TITLE: Modeling Tools for Two-Phase Electronics Cooling Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Compact Power Conversion EC

OBJECTIVE: Develop computational techniques and tools to accurately predict system-level performance of two-phase cooling systems.

DESCRIPTION: Next generation thermal management systems must be capable of acquiring, transporting, and rejecting high thermal loads. Advanced architectures currently being investigated often rely on two-phase fluid concepts which make use of the latent heat of evaporation to provide high heat transfer rates. Commercial software is able to model single-phase cooling systems due to the availability of experimentally-derived empirical correlations which accurately describe thermal and fluid behavior under most operating conditions. In two-phase systems, such a representation is often not possible because the fluid dynamics, phase change, and heat transfer within each component (heat sink, piping, condenser) depends entirely on the operating conditions. Physics-based descriptions of boiling heat transfer are incomplete and empirical correlations are frequently accurate over a very narrow range of conditions. System level analysis therefore requires a dynamic determination of the flow and thermal behavior of the individual components and analysis of the interaction among these components. Computational techniques for the accurate prediction of two-phase cooling performance requires both component-level and system-level model development.

PHASE I: Develop robust, physics-based models of two-phase cooling components, such as microchannel heat sinks, spray cooling modules, and condensers, which accurately describe their flow and thermal performance under a variety of operating conditions. These models should describe the behavior of both aqueous and non-aqueous thermofluids (fluorocarbons and refrigerants) in all flow regimes, including transitional behavior.

PHASE II: Develop fast and accurate computational techniques using the models developed in Phase I. Incorporate these algorithms into a system-level analysis tool which provides for component interactions and accurately predicts dynamic phenomena such as pressure oscillations and dryout. This tool should allow for both component- and system-level optimization.

PHASE III: Develop final software tool and commercialization plans using the knowledge gained during Phases I and II.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
The development of robust computational tools for the analysis of flow and heat transfer phenomena is directly applicable to both the military and private sectors. Examples of potential military and commercial applications include cooling power conditioning electronics, directed energy weapons, phased-array radars, and computer data centers.

REFERENCES:
1. L. X. Cheng and D. Mewes, “Review of two-phase flow and flow boiling of mixtures in small and mini channels,” Int. J. of Multiphase Flow 32, 183 (2006).

2. S. G. Kandlikar, “Heat Transfer Mechanisms During Flow Boiling in Microchannels,” J. Heat Transfer 126, 8 (2004).

3. K. M. Kelkar, S. V. Patankar , and S. Kang, “Computational method for characterization of a microchannel heat sink involving two-phase flow,” Proc. Interpack-2005, IPACK2005-73119.

4. W. Qu and I. Mudawar I., “Measurement and Prediction of Pressure Drops in Two-Phase Micro-Channel Heat Sinks,” Int. J. Heat Mass Transfer 46, 2737 (2003).

KEYWORDS: thermal modeling; two-phase cooling; boiling; high heat flux; power-conditioning electronics

N07-T030 TITLE: Influence Sweeping of Pressure Mines

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace

ACQUISITION PROGRAM: Unmanned Surface Vehicle Minesweeping PMS 495

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this effort is to identify and develop a practical technology, system and employment technique for unmanned sweeping of pressure mines in ports, harbors, shipping lanes and coastal approaches.

DESCRIPTION:
Existing Capabilities: Naval mine countermeasures emphasize systems, technologies, tactics and procedures for minehunting; that is the detection, classification, identification and neutralization of naval mines. In tactical situations or littoral environments where minehunting is not feasible, or does not sufficiently reduce the risk of mine damage to naval forces, minesweeping systems and tactics are employed to further reduce that risk. Existing mechanical and influence minesweeping systems employed by the fleet represent technology developed more than half a century ago. New technology for magnetic and acoustic influence minesweeping is in S&T development, will transition to the mine warfare mission package of the Littoral Combat Ship during the FYDP, and generally satisfies established requirements for influence sweeping magnetic and/or acoustically actuated mines.

Gap in Capabilities: Sweeping Pressure Mines.
Naval mines acuated by a passing ship hull’s pressure wave have existed for many years, but no practical means of sweeping these mines is readily available. Thus the sweeping of pressure mines remains an established Navy requirement, recently re-validated within the US Navy. Employment of pressure mines by an adversary is likely to be in the relatively shallower waters of ports, habors, shipping lanes or coastal approaches where wave action is minimized so as to not be a factor in actuation. The consequences of a commercial port closing due to a mine damaged vessel sinking in a ship channel have been the focus of many ongoing homeland defense activities involving technologists, system developers and operators.

Previous Solutions:
Efforts to develop technologies or systems to sweep pressure mines have not resulted in a practical, readily available and deployable unmanned system. Such efforts included sacrificial surface vessels, or large submerged tow-bodies. Sacrifical surface vessels would need to be large in order to develop pressure wave characteristics of the targeted vessels. Submerged tow-bodies develop significant drag and required very high powered towing vessels. These approaches to a solution were considered impractical, expensive to develop, maintain and deploy given the perceived level of threat at the time.

Fulfilling the Requirement:
A fresh look at solutions for pressure mine sweeping is warranted and responds to validated Navy requirements. Given the Navy's requirements for mine countermeasures solutions that decrease the tactical timeline for clearing mines, a solution that is readily deployable, possibly as part of the Mine Warfare Mission Package of the Littoral Combat Ship, or practical to maintain in major port areas is desired. Additionally, the desired solution should be employable without the requirement for onboard operators. A successful solution will operate in most environments where pressure mines are employed.

PHASE I: Provide an initial development effort that demonstrates an understanding of the problem, scientific merit and potential capabilities of a practical, deployable unmanned minesweeping system for pressure influenced naval mines.

PHASE II: Develop a practical, prototype system for demonstration, and demonstrate performance effectiveness on instrumented/exercise pressure influenced mines in typical environments. Phase II may require access to classified information.

PHASE III: Transition the technology to the ONR Mine Countermeasures Future Naval Capability program for further development and demonstration, or if maturity warrants, to the Naval Sea Systems Command program of record in minesweeping.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Under the US Maritime Operational Threat Response Plan, the US Navy is charged with clearing naval mines in US ports. Given this responsibility lies entirely within the operational military, the developed product is not expected to have a direct application or benefit to industry, other than the obvious impact to US commerce caused by naval mining of a US port, harbor or coastal shipping lane. It it expected that expeditious mine clearing would be enhanced by the availability of minesweeping gear within or in close proximity to all US ports where disruption of commerce would cause significant economic or strategic impact to the US.

REFERENCES:
1. Sea Mines & Countermeasures: A bibliography. US Naval Postgraduate School, July 2005.

2. FY06 US Naval Mine Countermeasures-Challenges and Vision. Chief of Naval Operations, August 2004

3. Operations Research in Wartime: Naval Mining. Journal of Operations Research, Vol 15, No. 1, Jan-Feb 1967

4. Naval Mine Warfare: Operational and Technical Challenges for Naval Forces. National Academy Press, 2001

5. New Techniques to Predict Ship Vulnerability to Pressure Mines Along Shipping Routes. Publication DSTO-RR-0126, Author: John C Barnes, Defense Science and Technology Office, Australia, February 1998.

KEYWORDS: Pressure Mines; Minesweeping; Naval Mines; Influence Minesweeping;Ship Vulnerability;Mine Countermeasures

N07-T031 TITLE: Human-Directed Learning for Unmanned Air Vehicle Systems in Expeditionary Operations

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Human Systems

ACQUISITION PROGRAM: Large Tactical Sensor Network Enabling Capability, FORCENet FNC

OBJECTIVE: To develop and demonstrate the technology to enable human operators to provide direction to unmanned air systems in adapting or learning new tactical behaviors. This should focus on tactical behaviors of interest for small unit expeditionary operations. Learning could be done on-line or as a more conservative option, this could be used only in a simulation or test environment as a way of developing new tactics that could then be implemented using more conventional approaches on real systems.

DESCRIPTION: Current autonomy technologies rely heavily on optimizing pre-determined tactics or behaviors and often require a considerable amount of workload by a skilled operator to effectively employ. While this can provide considerable flexibility and capability, it limits the ability of autonomous systems to deal with unexpected situations and to make full use of the new opportunities created by the use of autonomous systems. Ideally, it would be desirable to have autonomous systems be able to learn new approaches to solving problems, assuming they could do so in a computationally feasible way while remaining within safe bounds and acceptable rules of engagement. This could be done on-line or as a more conservative option, this could be used only in a simulation or test environment as a way of developing new tactics that could then be implemented using more conventional approaches on real systems. For on-line use, safety issues will be of concern and it will be necessary to give some thought to how validation and verification can be done. Overall, this type of capability might require some ability to assess the current situation, predict the future consequences of decisions using available data, and then make decisions on the most appropriate tactics or maneuvers to follow based on an assessment of the situation and the tasking/direction provided by a human operator. However, learning in complex and unstructured unmanned vehicle environments is generally very difficult. One of the most important reasons is the credit assignment problem. It can be very challenging to enable autonomous systems to understand what factors caused previous decisions to yield good or bad results. This is particularly difficult when there is a large state space and uncertain data, and when it is not always clear what the important features of the available data are that should drive learning. Further, this problem can be particularly difficult when multiple vehicles are involved. In addition, the unmanned vehicle may not have the understanding of context that a human operator does. For complex mission tasks, the cost function and constraints used for learning may not capture all of the important aspects of the problem and this may lead to results that are not practical in real operations. As a result it would be useful to enable humans to provide direction to unmanned systems in learning. Of particular interest are approaches for tactical behaviors that would support small expeditionary unit intelligence needs in monitoring a large and complex area continuously in order to identify potential threats and take action to prevent them. This could include threat avoidance and avoiding detection by hostile forces or at least confusing hostile forces as to the intent of the unmanned vehicle's data collection actions.

PHASE I: Develop an initial version of the proposed approach for a limited set of mission scenarios with sufficient functionality to demonstrate feasibility. For Phase I, a single unmanned system may be used, but additional systems would also be of value if feasible within the scope of the Phase 1 effort. Human-directed learning should include the ability to learn procedures to achieve goals and to respond to contingencies. Phase I should focus on human interactions with the system prior to execution of the mission tasks to support learning. Human inputs to the system may be simulated or pre-generated. Experimentation should include integration with limited-fidelity simulation elements to show some closed-loop performance and as much robustness and sensitivity testing as is feasible. Key metrics for Phase I may include number of human interactions required for training on a particular mission scenario (and/or amount of time if actual human is in-the-loop), percentage of correct decisions by autonomous system before and after training, percentage of correct responses to contingencies, percentage of errors that have a significant impact on task performance, time to complete mission tasks, number of tasks accomplished and percentage of constraints/Rules-of-Engagement violated (note that not all of these metrics are required within the scope of Phase I).

PHASE II: Further develop the proposed approach for a broader set of mission tasks and system types in a more complex dynamic and unstructured environment and integrate them with a medium-fidelity simulation and sufficient autonomy components to perform laboratory operator in-the-loop demonstrations and comparison with benchmarks. Ideally, inexpensive real platforms may be used for some of the experimentation. This should demonstrate capability with at least 2 types of heterogeneous platforms. Phase II may include some training during or after mission execution in addition to prior to mission execution. Revise evaluation metrics and interfaces as necessary. Key metrics for Phase II in addition to the Phase I metrics may include factors such as time for training, cognitive workload of the operator in training the system (e.g., modified Cooper-Harper scale or TLX), operator trust (e.g., Lee and Moray trust scale), and usability. In addition, Phase II should incorporate some understanding of how to show the reliability and safety of the system as relevant to the particular application.

PHASE III: Integrate the software with other naval unmanned system or naval tactical sensor network software and participate in integrated demonstrations of multi-vehicle operations with formal naval operator evaluations.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
This technology will be useful for a range of commercial unmanned system and other automation applications including search and rescue and other first responder uses.

REFERENCES:
1. Kaelbling, L. P., Littman, M. L., and Moore, A. W., "Reinforcement learning: A survey,"J. Artificial Intelligence Res. 4, 237–285, 1996.

2. Monaco, J.F., D.G. Ward, and A.G. Barto, "Automatic aircraft recovery via reinforcement learning: Initial experiments," Advances in Neural Information Processing Systems 10, (M.I. Jordan, M.J. Kearns, and S.A. Solla, Eds., MIT Press, 1998, pp. 1022-1028.

3. Fernandez, F., Borrajo, D., Parker, L., "A Reinforcement Learning Algorithm in Cooperative Multi-Robot Domains," Journal of Intelligent and Robotic Systems 43: 161–174, 2005.

4. H. Friedrich and R. Dillmann, Robot programming based on a single demonstration and user intentions, in 3rd Euro. Workshop on Learning Robots (ECML95), 1995.

5. C. Breazeal, A. Brooks, J. Gray, G. Hoffman, J. Lieberman, H. Lee, A. Lockerd, and D. Mulanda. Tutelage and collaboration for humanoid robots. International Journal of Humanoid Robotics, 1(2), 2004.

6. C. Breazeal, G. Hoffman and A. Lockerd, “Teaching and Working with Robots as a Collaboration.” Proceedings of the Third International Joint Conference on Autonomous Agents and Multi Agent Systems, 2004.

7. R.C. Arkin, Y. Endo, B. Lee, D. MacKenzie, E. Martinson, “Multistrategy Learning Methods for Multirobot Systems,” 2006. http://www-static.cc.gatech.edu/ai/robot-lab/publications.html

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9. Lent, M., Laird, J., “Learning Procedural Knowledge Through Observation,” Proceedings of the International Conference on Knowledge Capture,

10. S. Singh, A. Barto, N. Chentanez, “Intrinsically motivated reinforcement learning,” Proceedings of Advances in Neural Information Processing Systems 17, 2005.

11. S. Schaal, “Is imitation learning the route to humanoid robots?” Trends in Cognitive Science 3(6), 1999. 233-242

KEYWORDS: Unmanned Air Vehicle, UAV, UGV, USV, learning, tactical behaviors

N07-T032 TITLE: <u>Portable Friction Stir Welding Technology for Aluminum Fabrication</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: LCS, PMS 501, ACAT ID

OBJECTIVE: To develop and implement innovative technologies to allow the friction stir welding of aluminum structures in situations where standard, stand-alone friction stir welding machines cannot be used. The approach must develop uncomplicated, robust measures, which currently do not exist, to apply the necessary conditions to reliable friction stir weld marine-grade aluminum plate and wrought products for ship subassembly construction and repair applications. Achieving applied welding loads that would permit manual manipulation of the equipment during friction stir weld aluminum plate would be a goal of this project.

DESCRIPTION: The Navy's Program Executive Office for Ships is leveraging the National Research Program (NSRP) to effect change across the non-nuclear surface shipbuilding, modernization and repair enterprise by coordinating with U. S. shipbuilders to adapt and implement "World Class" commercial best manufacturing practices. The U.S. shipbuilding industry lags behind the global shipbuilding market significantly in adapting new technologies to long-standing inefficient manufacturing processes and improvement is this area is key to closing this gap.

This topic seeks innovative scientific and engineering solutions to extend a developing joining technology, friction stir welding, beyond its current limitations as a shop joining process that requires specialized and expensive facilities. This topic will require innovative approaches to apply and control parameters, maintain proper positioning of the structure and welding equipment and develop new tools to extend the technolgy beyond its current limits. This topic offers an opportunity to infuse new ideas/innovations into the domestic shipbuilding industry.

Proposals under this topic must address integration of the research areas identified. Efforts cited within each research area are illustrative only and proposals dealing with related efforts within each research area are also solicited.

1. Systems with emphasis on manual control and field application of friction stir welding for marine-grade aluminum ship structures
2. Friction stir tool material and geometry designs that will facilitiate low, normal (Z-axis) load condition for friction stir welding

3. Systems that minimize set-up, break-down and processing complexity during the field-applied friction stir welding process

Of particular interest are initiatives with a clear business case. Proposal should specifically describe the technology that will be applied to solve the problem, how it will be developed, what the specific benefit will be and how it might be transitioned into the shipbuilding industry. NSRP members are available to provide guidance and assistance in the identification of common issues and needs. Contact with these resources is encouraged both prior to proposal development and during any subsequent SBIR-related activity. Teaming with a NSRP member (or Government shipyard) is voluntary and will not be a factor in proposal selection.

PHASE I: Demonstrate feasibility for improvements being developed and also identify impact upon shipbuilding affordability. Include a first order Return-On-Investment (ROI) analysis for industry implementation and estimate potential Total Ownership Cost (TOC) reduction. Establish Phase II performance goals and key developmental milestones.

PHASE II: Finalize the design, as appropriate, and demonstrate a working prototype of the proposed system. Perform laboratory tests to validate the performance characteristics established in Phase I. Develop a detailed plan and method of implementation into a full-scale application

PHASE III: Implement the Phase III plan developed in Phase II in coordination with the shipbuilding and repair industry.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology developed under this topic shall be directly applicable to current military and commercial shipbuilding operation and repair practices. The products developed should find wide use in most heavy industrial plant/processing facilities such as the power industry and will be marketable to the shipbuilding and repair industry.

REFERENCES:
1. NSRP ASE Strategic Investment Plan, available on line at http://www.nsrp.org

2. Welding Capabilities and Technology at Marshall Space Flight Center, available on line at http:// www.asm-indy.org/dingjeff.htm

3. Aluminum Friction Stir Welding at Eclipse Aviation, availabe on line at http://www.eclipseaviation.com/about_eclipse/innovations/friction_stir_welding/

4. US Naval Shipyard information is available at http://www.shipyards.navy.mil

KEYWORDS: friction stir welding; portability, shipbuilding technology, affordability, manufacturing technology

N07-T033 TITLE: <u>Novel Initiators for Pulse Detonation Engines</u>

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: Program Executive Officer (Weapons), Air platform-cost reduction

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative fuel/air initiators/initiation concepts for pulse detonation engines and other pulse detonation devices, which promote rapid detonation initiation within a short length (relative to existing concepts). Develop analytical/computational tools to determine the minimum energy required for specific approaches and determine the power source requirements for detonation initiation in practical pulse detonation engines.

DESCRIPTION: Pulse detonation engines offer the potential of propelling weapons/vehicles from subsonic to supersonic speeds utilizing a relatively simple and scaleable configuration without ejecting boosters. Passive (predetermined) or active control of the firing frequency of individual tubes on multi-combustor PDE systems or the order of firing of tubes will enable thrust vector control without external control surfaces. This will be of significant advantage in high speed propulsion due to the reduction in drag by elimination of vulnerable external bodies in the final system. However, in order for the PDE technology to compete with conventional turbojet, ramjet and scramjet technologies, sustained repetitive initiation of detonation at practical power levels must be achieved. Conventional techniques such as, Deflagration-to-Detonation Transition (DDT) and shock focusing involve some flow-path pressure drop penalty and will reduce the competitive edge of PDEs. Repetition rates at the order of 100 cycles will result in acceptable aggregate energy conversion rates, a nearly uniform thrust, and produce specific thrusts comparable to conventional systems, but at a reduced fuel consumption rate. Any missed detonation may produce non-uniform thrust, inefficient operation, and may cause instabilities and vibrations that can lead to premature failure of the engine. The key issue in the development of PDE for Naval applications is the reliable and rapid detonation of heavy hydrocarbon/aviation fuels with very low aggregate power levels. These requirements are often contradictory and require innovative techniques. Shock-shock/shock-flame interactions, distributed discharges, plasma initiation etc. have been studied under the sponsorship of the Propulsion Program Office at ONR, and the findings are available for the proposer if required. The goals are primarily: reliability, acceptable size and weight, and very low energy consumption. The relative merits of the newly developed concepts can be evaluated and compared with current approaches. The most promising method can then be utilized in multi-tube engines and the propulsion system performance evaluated. Ultimately, incorporating this technology into PDEs may result in a lower cost propulsion alternative to compete with current technologies like turbine engines, ramjets, and scramjets for low speed and high speed weapon propulsion or as a unique technology for meeting certain requirements.

PHASE I: Design and test innovative detonation initiation system at laboratory scale in a configuration of choice. Perform parametric studies and develop predictive computations.

PHASE II: Based on the experimental data from Phase I and the computational tools, design, fabricate the optimized initiator hardware and power supply, and demonstrate repetitive initiation (about 100Hz) without missed detonations.

PHASE III: Design initiator hardware and power supply and integrate the system in an existing PDE facility. Demonstrate required test readiness levels (TRL). Provide design information for replacement with existing weapon systems (such as Tomahawk) or systems under development.

PRIVATE SECTOR USE OF TECHNOLOGY: PDEs are presently considered by industry for aircraft propulsion and several other applications. As this technology matures, it may benefit commercial aviation. Reduction in operational cost will favor reduced cost per passenger mile.

REFERENCES:
1. Roy G .D, “Combustion Processes in Propulsion”, Elesevier, 2006

2. Roy G. D, S. M. Frolov, A. A. Borisov, D. W. Netzer, “Pulse Detonation Propulsion: Challenges, Current Status, and Future Perspective”, Progress in Energy and Combustion Science, pp.545-672, Elsevier, 2004.

KEYWORDS: Combustion; Detonation; Missile Propulsion, Aircraft Propulsion; Specific Impulse; Fuel Consumption, Reduced Cost of Operation

N07-T034 TITLE: <u>Biometrics in the Maritime Domain</u>

TECHNOLOGY AREAS: Information Systems, Battlespace, Human Systems

ACQUISITION PROGRAM: Identity Dominance System – Maritime Domain, OPNAV N867

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop technologies to enable robust biometric identification of individuals at modest distances during expanded maritime interception operations.

DESCRIPTION: Accurate personnel identification and verification are important capabilities in the global war on terrorism, and shipboard, expeditionary biometrics are of particular importance in the maritime domain for informing decisions involved in interception operations and monitoring of watercraft traffic in critical littoral areas of operation. Both improved affordability and reduced risk can be achieved if the system can be used at operational distances of 20m-100m. For Biometrics use by the Navy, it is of particular interest to acquire biometrics of persons of interest in small or medium crafts, using self-contained shipboard or patrol vessel mounted systems. The system will complement, and should be able to use enrollment data from the Identity Dominance System – Maritime Domain and should support similar matching characteristics.

There has been considerable work in face recognition [1] and other biometrics including a DARPA program in human identification at a distance[2]. Under that program face recognition under extreme lighting [3] and at over 50m was evaluated [4]. It also evaluated gait recognition at similar distances and iris was demonstrated at 2-3 meters. However, those results were under controlled daylight conditions with cooperating subjects. For operational use 24/,7 operation on moving ships with moving and non-cooperative subjects is required.

To achieve 24/7 face and potentially iris recognition from ship to ship requires significant improvements in operational field-of-view [2] to address non-cooperative subjects, handling wide ranges of pose and illumination [2,3], advances in stabilization, and handling of motion blur, addressing atmospheric disturbances/spray to be expected in ship-to-ship imaging. The operational system may be originally aimed and zoomed on the ship of interest, but the remainder of the processing including focus, face localization and recognition/enrollment of all faces should be automatic. In addition system technologies need to be developed to formally evaluate this type of standoff biometrics.

To summarize, the overall goal of this STTR is to develop a system that can provide ship—to-ship biometric recognition with high accuracy in 24/7 operations. In addition, the system needs to support two typical operations: 1) high volume low security identification, quickly scanning the deck of a full ship, and 2) high security low volume identification in a smaller area of the ship or open watercraft.

PHASE I: 1. Conduct research on biometric technologies and develop a conceptual system architecture for a Maritime Biometric system with 24/7 operational biometric volume for recognition which can capture and perform face-based recognition from at least 50m (and/or iris based recognition from 10m).

2. Demonstrate the basic feasibility of detection/recognition at that range with moving targets with at least 10fps processing.

3. Develop detailed report addressing how final system will address large operational field-of-view, non-cooperative subjects, wide ranges of pose and illumination, stabilization, motion blur and addressing atmospheric disturbances/spray to be expected in ship-to-ship imaging.

4. Develop experimental test procedures to be used for validation in Phase II to show at least 90% recognition rates, over a large database of subjects, during daylight operation and 80% recognition at night.

PHASE II: 1. Extend Phase I efforts to allow for an increased range to target and implement solutions detailed in the Phase I report. Explore multi-biometric fusion (eg. face, gait, other behavioral measures) and its impact on identification performance.

2. Develop a working prototype recognition system (both software and hardware), which can capture long range biometric data from a human subject and uses the captured biometric data for identification and verification in a ship-to-ship setting

3. Provide experimental analysis consistent with the plan developed in Phase I.

PHASE III: Develop a working prototype biometric system that is compact and ruggedized for austere shipboard use. Provide for wireless transmission of biometric data in Navy acceptable format to a host ship. Validate biometric data acquisition and accurate identification performance, sensor on ship 1, subject on ship 2 and biometric database on ship 3.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Biometric recognition for high secure access is important to both military and commercial community. The added challenges of recognition from a moving platform to a moving platform will require development of more robust algorithms/systems that should be useful for other law enforcement and military operations. Less restrictions on subjects and larger field of view may allow their use in commercial applications such as surveillance and point-of-sale.

REFERENCES:
1. W. Zhao, R. Chellappa, A. Rosenfeld, P.J. Phillips, Face Recognition: A Literature Survey, ACM Computing Surveys, 2003, pp. 399-458

2. J. Phillips, “Human Identification Technical Challenges”, IEEE Int. Conf. On Image Processing, 2002.

3. R. Gross, S. Baker, I. Matthews, T. Kanade, Face Recognition Across Pose and Illumination, Handbook of Face Recognition, Stan Z. Li and Anil K. Jain, ed., Springer-Verlag, June, 2004

3. S.J.D. Prince, J. H. Elder, Y. Hou and Y. Oleviskiy, “Towards face recognition at a distance,” In Proc. IET Conference on Security, 2006.

4. M. Savvides, B.V.K. Vijaya Kumar and P. Khosla "Face verification using correlation filters," Proc. Of the Third IEEE Automatic Identification Advanced Technologies, 56-61, Tarrytown, NY, March 2002.

5. T.P. Ripokia and T.E. Boult, "Classification Enhancement via Biometric Pattern Perturbation". IAPR Conference on Audio- and Video-based Biometric Person Authentication, (AVBPA Springer Lecture Notes in Computer Science 3546) pp850-859, July 2005.

6. Yi Yao, Besma Abidi, Nathan D. Kalka, Natalia Schmid , and Mongi Abid , “High Magnification And Long Distance Face Recognition: Database Acquisition, Evaluation, And Enhancement”, Biometrics Consortium Conference 2006.

KEYWORDS: Biometrics, verification, recognition, identification, information fusion, access control, Face-recognition

N07-T035 TITLE: Advanced ASW Acoustic Transducers and Signal Processing

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: PMS 401, PMS 415, PMS 485, PEO-IWS5

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop new sensors and coupled signal processing techniques that achieve comparable or improved sonar system performance at lower cost.

DESCRIPTION: The performance of naval systems for Anti-Submarine Warfare (ASW) and Counter-Torpedo Detection, Classification, and Localization (CTDCL) is limited by the size, power, and detection range of current sensor systems. Although current systems are adequate for current missions, improved sensors and processing algorithms are required for maintaining tactical advantage against future adversaries.

This STTR will address these short falls through sensor technology and processing algorithms for both sources and receivers. Proposals may address combined sensor and processing concepts or separate sensor or processing concepts. In the technology area the goal will be to develop a high power underwater projector that operates below 1000 Hz, has the capability to produce in excess of 210 dB source level, has a 200 Hz bandwidth and is compact in shape. In the processing area the goal will be to develop a noise audit model for vector sensor towed arrays as a means by which to achieve environmental noise limited performance at lower frequencies and/or at higher tow speeds. Processing investigations will also include techniques to maintain processing gain with reduced acoustic source level: continuous acoustic transmission to ensonify submarine and torpedo targets and planning techniques for optimum placement of transducers.

PHASE I: Analyze the performance requirements for both the transducers and the processing algorithms, identify new transduction technology or a radical improvement in existing technology that can lead to a transducer concept meeting these performance criteria at a reasonable cost, and validate the approach through design studies. Employ the noise audit model to validate physics-based models of the broad wave number flow noise observed in vector sensor towed arrays.

PHASE II: Develop a prototype compact, high-power transducer and validate performance and design parameters through in-water testing. Combine adaptive signal processing techniques for exploiting the information available via the vector sensors with the improved understanding of flow noise to benchmark the resulting performance against flow induced noise in existing towed arrays. Make cost effective tradeoffs in the design of next generation vector sensor towed arrays for multiple applications in ASW and CTDCL.

PHASE III: Perform modifications to sensor processing algorithms to ensure suitability and compatibility with transition into the appropriate Acoustic Processing Build. Coordinate this transition with the processing working group established by the transition agent. Address sensor interfaces and mechanical factors necessary for transition into planned upgrades. Coordinate with the systems engineering and hardware working groups established by the transition agent.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The broad applicability and wide market for this technology across the Navy should lead to a commercially successful result even if only naval applications were supported. In addition, compact, high-power acoustic sources have application both in exploration for oil and natural gas was well as in studies of the geophysical properties of the ocean and the sea floor. In addition, the noise cancellation algorithms for vector sensor towed arrays could potentially allow higher search rates in seismic studies, both for scientific studies and for oil exploration. However, this application is longer term.

REFERENCES:
1. Charles H. Sherman and John L. Butler, "Transducers and Arrays for Underwater Sound", Springer, NYC (Nov 2006).

2. Norman L. Owsley, "Sonar Array Processing," in Array Signal Processing, S. Haykin ed., Prentice-Hall, Englewood Cliffs, NJ (1985), pp.161-164.

KEYWORDS: vector sensor; transducer; adaptive; underwater; noise cancellation; compact

N07-T036 TITLE: Compact Long-Range Underwater Velocity Sensor

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace

ACQUISITION PROGRAM: Mission Reconfigurable Unmanned Undersea Vehicle Program, PRE-MDAP

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate an underwater velocity sensor that can measure horizontal vehicle speed over ground from altitudes above the bottom of 10 ft to 1000 ft and speed through water simultaneously.

DESCRIPTION: UUVs need a bottom velocity sensor to determine or enhance underwater position estimation. A sensor with long-range altitude capability is needed to provide reliable and accurate submerged speed over ground. Existing velocity sensors that are compatible with 7.5”- to 21”-diameter UUVs have a maximum altitude range of less than 600 ft. This limitation restricts the range of water depths in which UUVs can operate. A sensor with improved altitude range will extend the regions where UUVs can conduct clandestine Mine warfare, Anti-Submarine Warfare, and Intelligence, Surveillance and Reconnaissance missions.

The following are more detailed characteristics to assist in development and integration into Navy UUVs. These are goals of the optimal sensors to assist in the research and design, not all goal may be able to be met:

-The sensor should reliably measure speed over ground with single-ping velocity accuracy of 0.02 knots at one standard deviation or better at speeds-over-ground of 1 to 7 knots, and in water temperature of 40ºF to 90ºF. The accuracy is more critical in shallow depths than deeper depths.
-The long-term velocity accuracy (scale factor) must be 0.4% or less.
-The sensor should be small enough to fit in a cylindrical section 18” long and 21”-diameter (threshold) [7.5”-diameter (objective)].
-It should be powered with 20VDC to 48VDC batteries, with average power consumption of 10w or less.
-The maximum velocity measurement rate should be 2 Hz or faster to 10 Hz.
-Ability to provide an along-track estimation and compensation with a still velocity accuracy of .002 knots

PHASE I: Design a bottom velocity sensor with performance characteristics as stated in the Objective section. Provide analysis to support the projected sensor performance.

PHASE II: Build and test bottom velocity sensors having the characteristics listed in the Objective section. Produce a documented interface to allow easy integration with a variety of underwater vehicle navigation and control systems.

PHASE III: Integrate sensor into a PMS 403 UUV test bed. Demonstrate operation at sea of the performance characteristics listed in the Objective section.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:
Technology developed in this program could find commercial application in offshore oil industry and research UUVs

REFERENCES:
1. The Navy UUV Master Plan. November 9, 2004. http://www.chinfo.navy.mil/navpalib/technology/uuvmp.pdf

KEYWORDS: UUVs; unmanned undersea vehicles; underwater navigation; velocity sensor;

N07-T037 TITLE: Automated Launch and Recovery of Small, Untethered Unmanned Underwater Vehicles from Unmanned Surface Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS420 = Littoral Combat Ship Mission Modules

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OBJECTIVE: To develop a system for automated launch, recovery and recharging of small, untethered Unmanned Underwater Vehicles (UUVs) from Unmanned Surface Vehicles (USVs).

DESCRIPTION: Unmanned Surface Vehicles of length 35-40' are being considered by the U.S. Navy for mine-hunting operations. In one approach, a USV carries one or more small, untethered UUVs into the operational area. The UUVs are envisioned to be 9-12" in diameter and are equipped with side-scan and forward-looking sonars. The USV would be capable of autonomously launching and recovering the small UUVs. The small UUVs would periodically return to the USV to have their batteries charged, download sonar data to the USV and upload new mission parameters from the USV. This concept requires an autonomous system to launch and recovery (L&R) UUVs to/from the USV as well as a mechanism to accomplish handling of the UUVs on-board the USV. For example, in the recovery phase, the L&R system would consist of a homing device on the UUV to bring it to the proper position relative to the L&R system during recovery, a coupling mechanism between UUV and the L&R system, and a mechanism to lift the UUV on-board the USV. In addition, the L&R system will have a connection to allow charging of the UUV's batteries, download of sensor data from the UUV to the USV and upload of new mission parameters to the UUV. The operation would be reversed during launch of the UUV. The desired benefit of this approach is to impart a longer time-on-station to the UUV, since its battery power would not need to be used to transit to the operational area and the USV would be available to recharge the UUV's batteries.

PHASE I: Develop a detailed design concept for an automated system that will provide launch and recovery of small UUVs (including a homing mechanism, a coupling mechanism (UUV to USV), a lift mechanism (of the UUV onto the USV)), on–board handling of the UUVs, recharge of the UUVs' batteries, a data interface between USV and UUV that provides download of sensor data from UUV to USV and upload of new mission parameters from USV to UUV. The small UUVs will be 9"-12" in diameter and 4'-12' long. The USV will be between 35'- 40' long. The system will be capable of launching, recovering and recharging at least 4 UUVs. A critical aspect of the system will be its autonomous operation.

PHASE II: Fabricate a prototype launch, recovery, on-board handling and recharging and data interface systems for 9-12" UUVs based on the design and specification developed in Phase I. Demonstrate the prototype system pierside or on a small, manned boat. If necessary, a small UUV will be provided as GFE.

PHASE III: Install and demonstrate prototype launch and recovery system fabricated in Phase II on a USV. Provide at-sea demonstration of ability of prototype system to launch, recover, recharge and provide data interface to a small UUV from a USV. Provide detailed drawings and specifications. Transition to PMS420.

PRIVATE SECTOR USE OF TECHNOLOGY: Small boat-builders and machinery automation industries will benefit from this topic. Commercial applications include use on oceanographic survey vessels, off-shore oil exploration and salvage ships.

REFERENCES:
1. Sokol, W, "Unmanned Sea Surface Vehicle (USSV) S&T Program – Phase 1", Proceedings of the AUVSI Conference, 2004.
2. UUV Master Plan: A Vision for Navy Development, Barbara Fletcher, SPAWAR http://www.spawar.navy.mil/robots/pubs/oceans2000b.pdf

KEYWORDS: USV; UUV; Launch; Recovery; Minehunting; Automation

N07-T038 TITLE: Development of approach/instrument to non-invasively monitor/measure formation of nitrogen bubbles

TECHNOLOGY AREAS: Biomedical

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OBJECTIVE: To develop an approach to non-invasively monitor and measure the formation of nitrogen bubbles both in the bloodstream and in tissue, for the purpose of generating data to better characterize and qualify the physical etiology of decompression sickness (DCS) and revolutionize treatment of DCS.

DESCRIPTION: DCS is caused by the formation of small bubbles in the bloodstream and has long been a major concern in any activity requiring significant change in the ambient environmental pressure. As such, DCS is a significant hazard to Navy divers and astronauts. Currently, bubbles may be detected using Doppler ultrasound. However, Doppler has several disadvantages as a detection technique in that Doppler is sensitive to motion and bubbles have to be greater than 80 µm in diameter. In addition, Doppler data is very subjective and very difficult to standardize.

Currently, divers rely on decompression tables which are designed to decrease the incidence of DCS. Since the tables are based on reducing the statistical risk for an individual based on a population-based norm, there is no allowance to individualize preventive measures. Thus, a diver may have to undergo several hours of decompression when perhaps one hour of decompression would have worked. This detail becomes more salient when divers do not have access to a recompression chamber and have to undergo in water decompression. This significantly increases the risk to the divers, especially in times of turbulent sea state. In addition to divers, astronauts may suffer DCS during extra-vehicular activity (EVA) in space suits pressurized to only a third of an atmosphere. In fact, most astronauts undergo a lengthy oxygen pre-breathe before EVA. Thus, both activities suffer significant decreases in work efficiency in their respective environments. Despite over a century of dealing with DCS, tabular decompression tables remain statistical and experiential—and in fact, the appropriate decompression time can vary from person to person, and from time to time within a given individual.
The U.S. Navy is interested in developing an approach to monitor and measure non-invasively the formation of nitrogen bubbles both in the bloodstream and in tissue, for the purpose of generating data to better characterize and qualify the physical etiology of DCS and perhaps enhance treatment strategies. A body of anecdotal evidence suggests that reducing the number of tissue micronuclei by various pre-breathe strategies might greatly reduce the risk of DCS. Alternatively, detecting the quantity and/or size of micronuclei may predict the risk of DCS. An improved method to monitor/detect formation of bubbles would lead to a new tool in the prevention, detection and treatment of DCS.

PHASE I: Provide initial development effort that demonstrates capabilities of proposed bubble imaging system. This phase would provide key information about the uses and limitations of the system.

PHASE II: Use instrument/algorithms to correlate amount/size of bubbles with clinical signs of DCS. Other areas of research would be detection of what tissues contain bubbles and if tissue bubbles appear before intravascular bubbles. This phase would involve animal trials.

PHASE III: Determine the capability to detect bubbles in humans and correlate amount/size of bubbles with clinical signs of DCS and generally characterize the pathophysiology of DCS in humans. This phase would concentrate on hardening the equipment/standard operating procedures so that the device could be used by surface supplied divers undergoing in water decompression. Since surface supplied divers have a connection to the surface, telemetry of data would not be necessary. However, cables and couplings would need to operate in a sometimes challenging environment.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology would be of interest to not only the military diving community and NASA, but also commercial (underwater construction and oil companies) and the large recreational diving communities.

REFERENCES:
1. Acta Astronaut. 2005 May-Jun; 56(9-12):1041-7.

KEYWORDS: DCS; bubble detection; micronuclei; tissue bubble

N07-T039 TITLE: Isolating and Locating Speakers in Clutter

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PM Intel

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OBJECTIVE: Development of automated algorithms for identifying a specific person in a crowd based on voice characteristics. The desired outcome is a system that can match the features of a previously obtained noisy voice track to a newly acquired cluttered recording. This would allow military or law enforcement personnel to identify people of interest in remote or crowded areas using sensors on stationary or moving platforms. Additionally, algorithms should be able to separate out specific words from a noisy audio track in order to accurately piece together the many conversations that take place in crowds.

DESCRIPTION: For many years the so called “cocktail party” problem has been of interest to the law enforcement and military domains. In current U.S. operations, urban clutter has made the identification of specific enemy combatants extremely difficult. Better utilization of sensor data would be of great benefit, allowing tracking and planning based on specific enemy location.

Pulling a single voice out of noise and clutter for the purpose of speaker recognition can be very difficult when voices with similar audio characteristics are present. A complete solution will probably have to fuse a variety of characteristics in order to reduce the error rate.

Use of adaptive signal processing techniques can be of benefit for filtering noise and clutter to recognize a specific speaker. The ability to subtract out the noise of an engine and other noise on the sensor platform is important for obtaining the best quality signals for recognition. Fusion of signal characteristics may have to be addressed through neural nets or Markov models. The “fused” product needs to have high enough accuracy to allow specific conversations in clutter to be clearly understood.

In addition to the isolation of words and accurately mapping them to specific speakers, the topic is also interested in voice recognition algorithms. This problem is made difficult when the samples to be compared have already been processed and are at different quality levels. The combination of speaker identification (finding all the speakers in a signal) and speaker verification (do any of the speakers identified in the new clip match a library of known voice prints) will be a very powerful capability for law enforcement and the military. Like all level 1 fusion problems, the computation of confidence levels for all asserted inferences is critical.

In addition to using fusion methods to solve the association problem of the “next word” and voice track to voice track, the offeror may want to consider the fusion of signal processing algorithms used in the pre-processing of a signal.

PHASE I: Conduct research to evaluate the viability of combining signal processing and fusion techniques to develop a capability to isolate and understand specific spoken conversations in clutter. It is expected that performance predictions will be developed during phase 1 for all algorithms proposed by the offeror.

Algorithms to associate all spoken words to specific speakers using an array of voice characteristics.

Algorithms to reconstruct spoken conversations conducted between 2 or more people.

Algorithms to accomplish speaker recognition models relevant to include noisy, cluttered and perhaps pre-processed signals.

Algorithms to associate the next spoken word to words previously spoken
Algorithms capable of word association relevant to an environment containing voices with similar audio characteristics.

Additionally, during phase 1 the best implementation platform for real time, or near real time, implementation needs to be identified. Lastly the performer should describe the data collection system that will be required for good system performance.

PHASE II: A Phase II should accomplish the following tasks:
Develop automated tools for near real time speaker identification
Develop automated tools for matching voice prints collected by different systems

Develop automated tools for specific conversation transcription

Build a prototype system able to interface with Marine Corps tactical intelligence sources

Conduct a demonstration of the prototype on real-world data

PHASE III: A Phase III effort should accomplish the following tasks:
- Transition to a HUMINT collection program of record
- Transition to a commercial law enforcement product

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology developed under this topic would have direct application to civilian law enforcement.

REFERENCES:
1. Dan Edidin & Casazza Solve the “Cocktail Party Problem” http://rcp.missouri.edu/articles/casazza-edidin-cocktailparty.html

2. Campbell, W.M., Reynolds, D.A., Campbell, J.P., “Fusing Discriminative and Generative Methods for Speaker Recognition: Experiments on Switchboard and NRI/NTO Field Data,” Proc. Odyssey: The Speaker and Language Recognition Workshop in Toledo, Spain, ISCA, pp. 41-44, 31 May - 3 June 2004.

3. Reynolds, D.A, “Channel robust speaker verification via feature mapping,” 2003 IEEE International Conference on Acoustics, Speech and Signal Processing, 2003, Proceedings

4. Wan, V, Renals, S., “Speaker verification using sequence discriminate support vector machines,” IEEE Transactions on Speech and Audio Processing, march 2005, Vol 13, Issue 2.

KEYWORDS: Adaptive signal processing, speaker verification, fusion